DeskArtes

Industrial Design System

Ceramic Tutorial

First Edition

David Cheshire: "A Practical Guide to Computer Based Ceramic Shape Design".

February 1998

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Trade Marks

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INTRODUCTION
The System

DESKARTES is a Computer Aided Industrial Design (CAID) system which has certain facilities which make it an ideal tool for the Ceramic Shape designer. It covers all the stages of design from first sketches to final models. It connects to DeskTop Publishing (DTP), Computer Aided Drafting (CAD), Engineering and Manufacturing (CAE/CAM), and Rapid Prototyping (RP) systems.

Using DESKARTES you may easily create different forms for your designs. Different design alternatives can be experimented with and compared on the computer screen until the optimum solution is found. You may freely experiment with shape, colours, materials, and textures. Produce preview renders of your designs as you work, tuning them up to photographic quality final presentation renderings, with features like mirror reflection, transparency, and textured surfaces. On completion, your design information can be electronically transferred to other systems and output devices via one of many international standards. DESKARTES is easy to learn, yet powerful and efficient to use.

About this Tutorial

This Tutorial is designed for you to quickly become acquainted with the use of the DESKARTES industrial design system for designing ceramic products. In fact, it goes through practically *all* the functionality within DESKARTES. Spend a couple of days with the Tutorial now, and you'll get to know the most efficient ways to create your own designs. Or just skip this Tutorial, and enjoy a much longer time banging your head against the wall.

Before you begin

Before you start using this Tutorial, you should have DESKARTES installed on your workstation, you should have the workstation switched on, you should have logged in, and you should have the Motif windowing environment running. If you have trouble with any of these, please consult the installation instructions in the DESKARTES Technical Manual, or call your DESKARTES or workstation dealer.

Command Reference

A full explanation of every command is included in the DESKARTES Reference Manual. You may wish to refer to it from time to time if you meet with a particularly interesting subject, or if you run into any trouble.

Notation

Pay attention to the text in the margin: it contains information of importance to you as you progress.

New terminology in the text is introduced with ***bold italic*** typeface. Other important words and phrases are emphasised with *plain italic*.

The names of menus, commands and buttons, as well as other computer terminology, are printed in `This Typeface`.

Command shortcuts are expressed in brackets, *e.g.*, `[b]`.

Editing functions are written with bold typeface, *e.g.*, **b**.

Parts and Lessons

The Tutorial is divided into four major Parts, called Basics, Modelling Principles, Visualisation, and Advanced Modelling. The Chapters are further divided into Lessons, each with their particular subjects to teach.

🕐 2 – 4 hours.

The Basics Part consists of four Lessons. They teach you the general user interface and interaction principles, while you design and render a simple example model. It will give you a feel on how DESKARTES is operated, and build up your confidence before moving on to more challenging designs.

🕐 6 – 10 hours.

The Modelling Principles Part consists of six Lessons. The first Lesson is still concerned with quite basic functionality, such as editing and transforming curves. The next four Lessons go into the more powerful modelling techniques available in DESKARTES, building, trimming and blending of surfaces, using command sequences, etc. These exercises allow you to create quite a demanding, pleasing model. The final Lesson in this Part teaches you to produce dimensioned drawings of the model, and how to transport it to other systems.

🕐 4 – 6 hours.

The Visualisation Part has five Lessons that cover all aspects of visualising the model you've just created. It includes composing the scene, assigning material properties and textures, setting of light points, different modes of fast shading, using DESKARTES's painting program, and finally, producing photographic quality images with ray tracing. As you proceed, you'll also learn about various ways of file management with DESKARTES.

🕐 Take your time!

After these three Tutorial parts, you will be capable of producing many of your own designs and may want to take time out to practice and consolidate what you have learned. When you feel confident with the fundamental design methods, you may progress to the Advanced Modelling Part. Its four Lessons give you a chance to complete further exercises, and teach you which techniques are best used for different kinds of work.

Technical Notes

DESKARTES has been designed to be as tolerant as possible against any kinds of errors. However, something may always go wrong. To avoid the unnecessary errors, you are requested to keep in mind the following ground rules while working through this Tutorial:

- *Most commands can be interrupted.* Once you have started a command or an editing function, the command can be cancelled by clicking on the cancel button of any dialogue box.

  After the command is completed, you may use UNDO in the settings window (at the right), or with one of the edit mode undo functions.

- *You may not execute several commands at the same time.* Trying to start a new command in the middle of the previous one is usually prevented by the system, but it could lead to an error if attempted.

In the worst case, erroneous actions may actually *crash* the program. However, even if this should happen nothing is lost! No matter what caused the problem, even a power failure, you may always *continue* right from the latest modelling situation by following these simple steps:

- Start DESKARTES as described at the beginning of Lesson 1,

- Select your model directory, as described at the beginning of Lesson 5,

- Select the UNDO command from the settings window.

Demo version

If you haven't actually purchased DESKARTES yet, you may be running a ***demo version*** of the software. This will be highlighted by the words "Demo Version" in the title bar of the DESKARTES user interface window.

The demo version enables you to try out all of the functionality, but it puts certain limits to the visualisation accuracy, and it won't allow you to output any files. In particular, this means that the UNDO command won't work on the demo version!

PART I: BASICS

The following four Lessons give the first introduction to using DESKARTES. You will design and visualise a small bottle, consisting of a bottle and a cap. This is a very simple shape and the intention is to give you a quick overview of the general procedures required to design models. Later in the Tutorial, you will create more complex models using the same procedures described here.

You will learn how to start and finish a modelling session, create your model directory, create curves, make simple surfaces by rotation and, finally, save your work. You will also be introduced to controlling the way your model looks on the screen and rendering the object with fast shading. Pay particular attention to the hierarchy of objects described here as this is fundamental to all modelling work in DESKARTES.

Illustrations are provided to help clarify the design process, but you might wish to do something a bit different adding your own design flair. You may do so, but the first time you work through the Tutorial it is recommended that nothing too radical is attempted. Later, when you fully understand the procedures, you can return to the Tutorial and let your imagination run wild!

Lesson 1 : Getting Started

In this Lesson you will learn the basic techniques you will use every time you start modelling. You might get the feeling that you have to do a lot without anything interesting happening. However, be patient: once you familiarise yourself with these basic routines, you will be able to concentrate on the actual modelling.

You will learn how to

- use the mouse

- start DESKARTES

- make a model directory

- work with pop-up windows and menus

- work with pull-down menus

- work with dialogue boxes

- create the objects you need for your model

Meet the mouse

DESKARTES is *mouse* controlled. The mouse is the small device attached to your workstation by a wire, sitting on a pad usually to the right of your keyboard. When you move the mouse, a small object moves on the screen. It is called the *cursor*.

Rest your hand on the mouse with it's 'tail', the wire away from your arm. When you move the mouse forward away from your body the cursor should move up the screen, when you drag the mouse towards you the cursor should move down the screen. Left and right movements of the mouse will be similarly imitated by the cursor.

In the beginning, you might find it a bit difficult to get the cursor to go where you want. Don't worry: it doesn't take long for it to become a natural movement. Also, note that if you run out of space on the mouse pad, simply lift and move the mouse to a better position: the cursor only moves when the mouse is on the pad.

The position of the cursor is very important: it often determines what happens when you do something, such as pressing one of the mouse buttons, or a key on the

keyboard. Usually, you do things by *pointing* with the cursor, and *pressing* or *clicking* one of the three mouse buttons.

The shape of the cursor varies according to the situation, giving you visual feedback. Much of the time it looks like an arrow. At other times it might look like a cross or a watch.

Starting Up – Silicon Graphics

The command that starts DESKARTES is "DA". Move the mouse so that the cursor (that looks like an x) is within a ***command shell window***. A window is a rectangular object on the screen of your workstation, consisting of a frame and something inside.

The command shell window displays a ***prompt***, for example:

```
deskartes%_
```

The appearance of the prompt may vary on you system.

To start DESKARTES:

1. *Hold* the Shift button down, type DA (while still holding the Shift key), and hit the Return (↵) key.

2. Wait a while.

?   *Nothing showed on the screen when I typed DA.*

You didn't have the cursor within the command shell window. Move the mouse so that the cursor is in the window, and try again.

?   *DESKARTES didn't start when I typed DA and hit the Return (↵) key.*

If you didn't make a typing error, you have a problem with the installation. Refer to the installation instructions in the DESKARTES Technical Manual, or ask your software dealer for help.

Using Windows NT, starting up is a two-stage process. It is first necessary to start the window manager before starting the DESKARTES software itself. The commands for each of these procedures are found on the ![Start] menu at the very bottom of the screen. To start the window manager choose the command HWM Window Manager from Programs under the ![Start] button. After a few seconds, you should notice an Icon Manager window appear usually in the top left-hand corner of the screen. Now to start up DESKARTES, choose the command Industrial Design System again under the ![Start] button. These menu choices can be seen in the following diagram. It is possible that your system will not appear exactly as the diagram but you should be able to locate the commands.
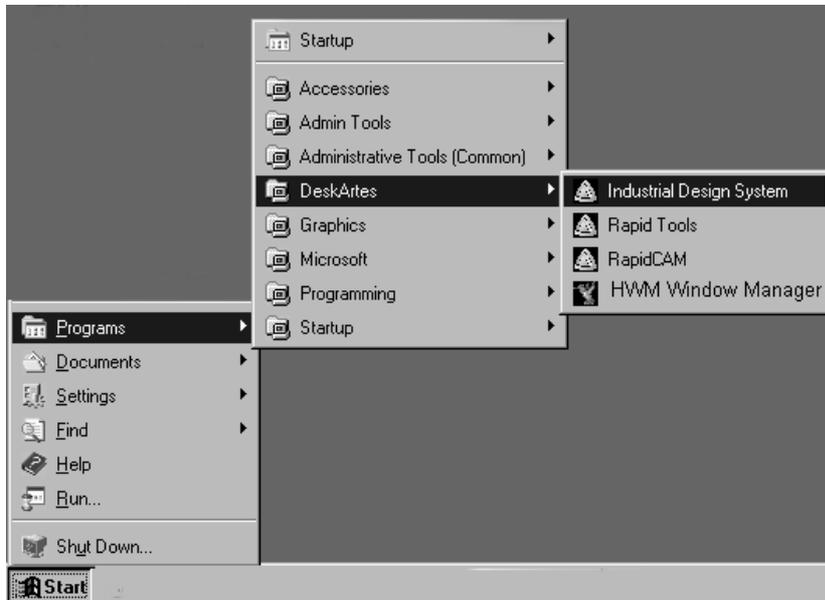
? *DESKARTES didn't start.*

If you didn't make an error, you have a problem with the installation. Refer to the installation instructions in the DESKARTES Technical Manual, or ask your software dealer for help.

The User Interface

After a while, the system displays the DESKARTES user interface. This will appear identical on both Silicon Graphics and WindowsNT computers.
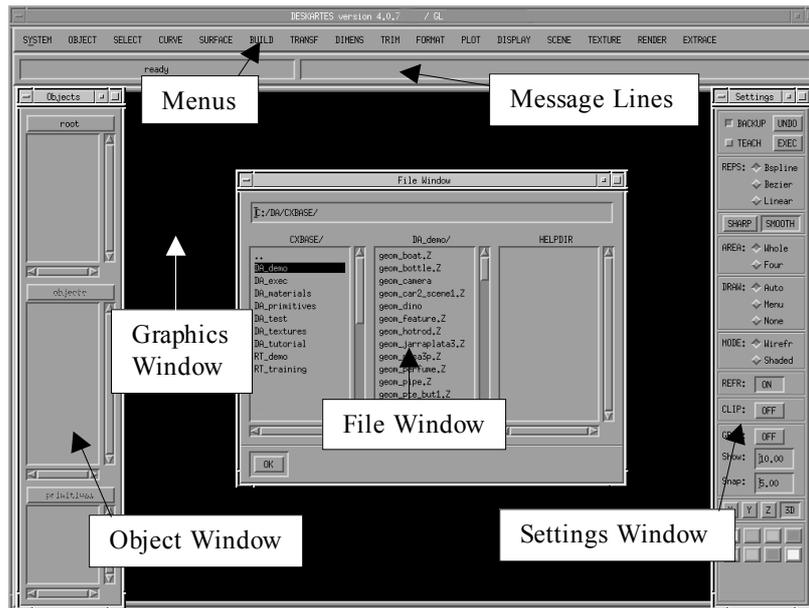
Making a model directory

The first thing you need to do when you start working with DESKARTES for the first time is to create a *model directory*. A model directory is like a folder where you store all your models. By storing different people's models in different directories we keep them in order. You could also use different folders for different ranges of products or any other way of differentiating your work.

You will handle directories and files with the commands within the DESKARTES *file window*. The file window appears and disappears again if you click the *middle* mouse button in the main graphics window. When DESKARTES is started, the file window is automatically displayed.

The file window is divided into three vertical fields containing lists of information.

File Window

C:/DA/CXBASE/

CXBASE/	DA_demo/	HELPDIR

CXBASE/ list:
- ..
- DA_demo
- DA_exec
- DA_materials
- DA_primitives
- DA_test
- DA_textures
- DA_tutorial
- RT_demo
- RT_training

DA_demo/ list:
- geom_boat.Z
- geom_bottle.Z
- geom_camera
- geom_car2_scene1.Z
- geom_dino
- geom_feature.Z
- geom_hotrod.Z
- geom_jarraplata3.Z
- geom_mesa3p.Z
- geom_perfume.Z
- geom_pipe.Z
- geom_pte_but1.Z
- geom_sofa.Z

OK
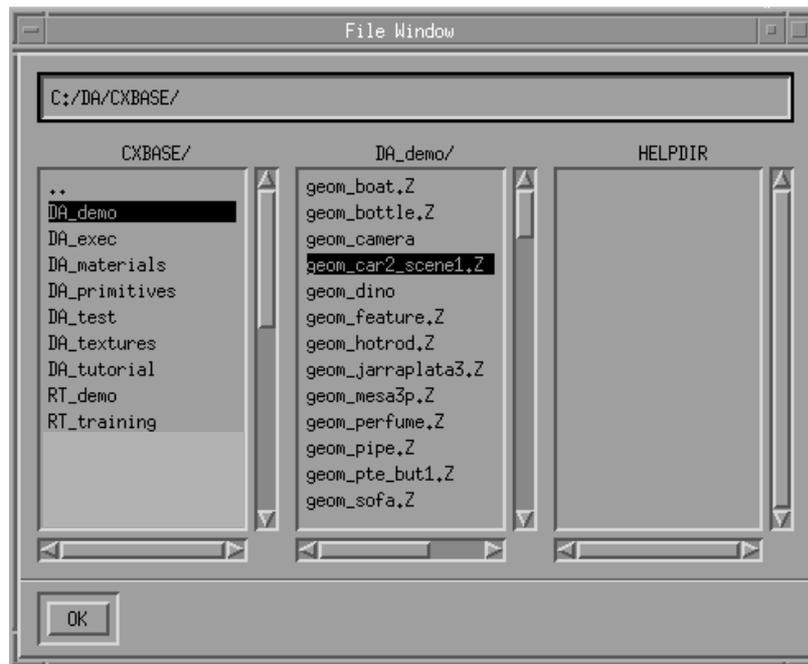
To create your own model directory:

1. Move the mouse so that the cursor is over the left-hand field of the file
   window. *Press and hold* the *middle* mouse button. A list of commands
   ("*menu*") pops up.

2. Still holding the mouse button, find the line that reads DIRECTORY:
   CREATE NEW. *Move* the cursor on to it so that it is highlighted. *Release*
   the mouse button.

From now on, whenever you are told to select something from a pop-up menu, do as
here: move the cursor to the required location, press and hold the middle mouse
button, drag the cursor to the desired item, and release the mouse button.

A *dialogue box* pops up above the file window. DESKARTES pops up a dialogue box
whenever it needs you to give some additional information.
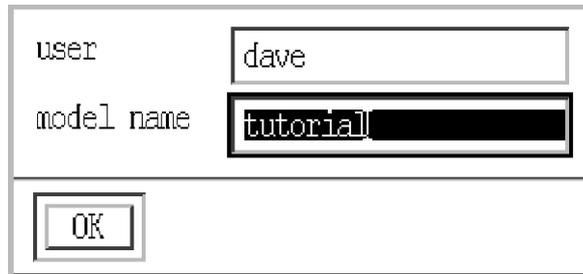
1. The part of the dialogue box that says

   ```
   user:
   ```

   is highlighted. Move the cursor into the dialogue box, and type your name
   or your initials (as "dave" above). Use the Backspace (←) key if you
   make a typing error.

2. Click at the second line or press the tab key, which says

   ```
   model name:
   ```

   Type

   ```
   tutorial
   ```

3. Click on the OK button at the bottom left corner of the dialogue box when
   you have finished, or press the return key to the same effect.

Now that you have created a model directory for the bottle, you should hide the file
window.

4. Click on the OK button in the lower left corner of the file window.

You are now ready to start modelling.

Initialising the model

Object hierarchy

Within DeskArtes, the things you design consist of *surfaces*, which are in turn
defined with *curves*.

! When asked to
type something
into a part of a
dialogue box,
click to select
that part with the
cursor, then type.

! To move to the
next field in a
dialogue box, you
could also press
the tab key on
the keyboard.

Curves and surfaces that belong together are stored in so-called *elements*. In other words, an element usually contains a surface with all the information that defines it.

Finally, the top or *root level* contains all the elements within a model.

For instance, the bottle you are about to create will consist of two elements, the bottle and the cap. Each element holds the corresponding surfaces and the curves that define the surfaces. This hierarchy is displayed in the *object window* on the left of the screen.

Creating an element

To be able to design something, you must first create an element in which to store part of your design. You will always start creating a new model by making an element for it.

To create a new element:

1. Move the cursor into the tall window at the left side of the screen (the object window).
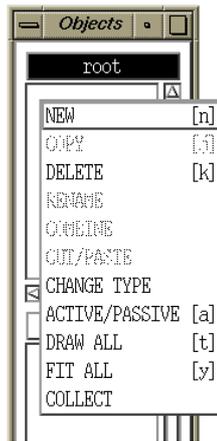
2. Select the NEW command from the object window pop up menu. (Press and hold middle mouse button, locate command, move mouse to it, release button. Remember?)

3. Type `bottle` into the dialogue box that appears and click `OK`. Make sure that the cursor is within the window before you start typing.

Look at the object window, on the left side of the screen. It has three sub-windows. The top sub-window is titled `root` (the root level described earlier!). Inside the sub-window, you see the text `bottle`, which is highlighted in black. This is the element you just created. At this stage of course it is nothing more than a name ready to store one part of your design.

Menu commands

Before moving on, let us have a look at the *menu bar* across the top of the screen. The menu bar has several names that group together commands with similar functions or that operate on similar objects. When the name of a menu is clicked a list of all of the options in that menu is displayed.
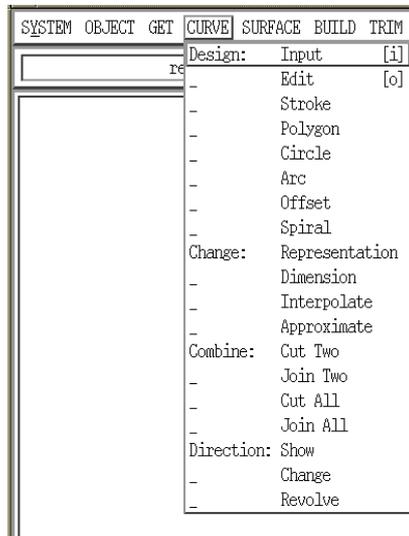
The command you just used to create a new element can also be found in the menu bar. In fact we will use it in just a while, but let's first just practice bringing up a menu.

To view the menu contents:

1. Locate the `OBJECT` menu. It is situated within the menu bar at the top of the screen. Place the cursor so that it is on the text that reads `OBJECT`.

2. *Press and hold* the *left* mouse button. The menu pops up.

3. This time, don't select anything from the menu. Keep holding the mouse button and move the mouse so that it is away from the menu. Release the mouse button, and the menu disappears.

Note on command names

From now on, a command from a window's *pop-up menu* is written as "Window⇒ COMMAND", *e.g.*, Object⇒ NEW [n].

Commands which belong to the menu bar (*pull-down menus*) are written as "MENU⇒ Command", *e.g.*, OBJECT⇒ New [n].

The "object" commands may be chosen either from the pop-up menu, or the pull-down menu, whichever you prefer. There is no risk of confusion, by the way. All the pop-up menu commands are written in capital letters, and those in the pull-down menus in lower case.

Shortcuts

Note also the *keyboard shortcuts*. which are assigned to the most often used commands, such as [n] for OBJECT⇒ New. The available shortcuts are shown within brackets [ ] after the menu items.

You know where and how to find commands.

You can execute a menu command simply by hitting the shortcut letter on the keyboard when the cursor is over the main graphics window. Once you learn the shortcuts, this is much faster than going to the menus with the mouse.

Curve sets

Now let's get back to what we were doing. You have created an element for the bottle. Next you will start designing some curves in it.

However, curves are not stored directly under elements. You must create a *curve set* to hold your curves. This is because curves can be used to control different things in DESKARTES.

Basically, there are two main kinds of curve sets: *projection sets* and *section sets*. The type of curve set determines the way DESKARTES uses the curves to make

surfaces. Projections define the surface's side view, while section curves give the surface its cross-sectional shapes.

For the bottle you will create a projection set, defining the surface's shape from the *x-direction* of the three-dimensional space.

Creating a curve set

To create an x projection set:

1. Select the command OBJECT⇒ New [n] from the main menu bar: bring up the menu as explained above, move the mouse to the first menu item, and release the mouse button.

2. Now a dialogue box pops up, asking what type of an object you want to create. Click at the line that says

   projection

   and click at OK.

3. Another dialogue box pops up, asking which projection direction you want. You want to create an x projection set, so click at x and then at OK.

Now you have an x projection set for your curves. In the middle sub-window of the object window (entitled bottle, the name of your element), you see the text Projections/X. This is the set you have just created. Currently it is just an empty 'name' ready to store a curve.

Now you are ready to actually start designing!

In the next few pages, you will design a bottle based on its *side view*, like this:
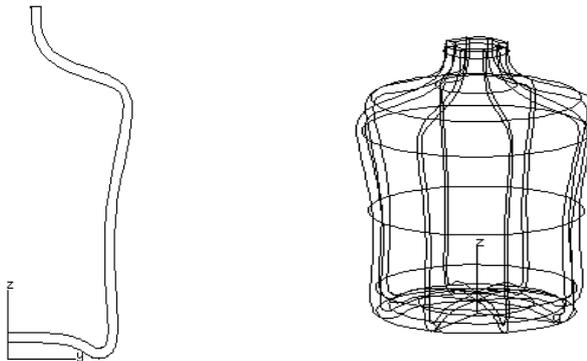
The curve only shows half of the bottle because you will finally rotate the curve 360 degrees around the vertical, z, axis to make a circular bottle.

Inputting the curve

For designing the curve we will use a reference *grid* to help locate the points.

Using the grid

The grid helps you to gauge the size of an object, and allows you to place the curve points accurately at fixed spacing. The grid commands are located in the vertical window on the right of your screen entitled the *Settings*. This window contains many regularly used functions.

To use the grid :

1. Click at the `Grid: OFF` button in the settings window on the right hand side of the screen.

```
Grid:   ON
Show:   10.00
Snap:   5.00
```

The OFF text changes to ON, and the grid is displayed.

2. The density of the visible grid lines may be controlled with the Show parameter below Grid.

3. The co-ordinates of any point placed on the screen will be rounded to the nearest multiple of the Snap parameter. The Show parameter value is normally a multiple of Snap.

You may change either one or both of these values by typing a value into the number field. However, if you change the Show value, the change will be shown on screen only after your next displaying command. Before continuing with the next section make sure the Grid is ON with a Show of 10 and a Snap of 5.

Input mode

To start designing the curve, you must get into the correct *mode* for entering the curve points. DESKARTES works in several different modes: *command mode* is where you have been so far. There you handle *objects* (or pictures) using the ordinary menu commands.

The modes for working with individual *points* (curve points, light points, pixels, etc.) are called *edit modes*. There you will use what we call *functions* and the ordinary will commands not be available.

We will next enter one of the edit modes, the *curve input mode*. To start the curve input mode, you must choose the appropriate command from the CURVE menu.

To input a curve:

1. Check to see that the x projection set you created is still highlighted in the object window. If not, click on it.

2. Select the menu command CURVE⇒ Design: Input [i].

Now you are all set to draw the curve. Notice that some small pictures, or *icons* appear. This happens with all edit modes. The icons represent the editing functions, and vary for the different edit modes, depending on which functions are relevant for the type of editing.

DESKARTES represents curves by using a ***control polygon***. A control polygon is a series of connected line segments. At each of the corners you might like to imagine a magnet which pulls on the curve so that it generally follows the shape of the control polygon. When you input a curve, you place the corners of its control polygon, *i.e.*, ***control points***.

This means that at first when you add points they will be joined with straight lines. Don't worry, when you've finished adding points DESKARTES will smooth these out to form a curve.

Creating a point

Place the first point:

1. Find the icon for adding a point (as the image above). Click on it.

2. Move the cursor on top of the vertical axis and click the *middle* mouse button. The point drops there.
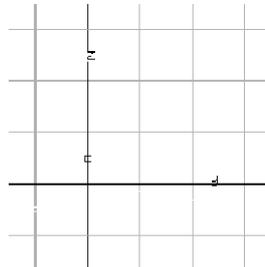
Notice that the top left corner of the icon shows a picture of the mouse with the middle button highlighted. This means that you don't need to click at the icon every

time you want to add a point— simply press the middle mouse button directly where you wish to place the point.

Similarly, all other icons have a *function key* at their top left corner. For most of the icons, this is a letter, and for others, it is a mouse button. To perform the function, simply hit the key in question.

Now, place the second point to the left of the first one. Try using the middle mouse button directly instead of going to the icons. Press and hold the middle mouse button to create the point, move the cursor to where you want the point to be (to the right of the first point, as shown below), and release the mouse button.
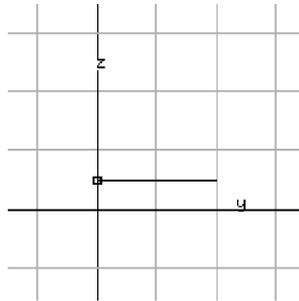
If you made an error in placing the point, you may backtrack with the following function:

Removing the last point

To remove the last point:

- Click on the eraser icon,

- or click the *right* mouse button.

Try it and see the last point vanish.

Completing the curve

Now, place the rest of the points the same way you placed the first two.

To complete the curve:

- Move the mouse and use the middle mouse button to place the rest of the points. By counting the grid squares try to copy the shape of the curve in the above diagram as closely as possible.

Getting out of input mode

To get out of input mode:

You have drawn a curve.

- Click on the Smile icon, or press **w** on the keyboard.

The icons vanish, and the polygon changes to a smooth curve.

Turning off the grid

We have finished with the grid so we can turn it off now.

To turn off the grid

- Click at the Grid: ON button in the settings window.

The OFF text changes to ON, and the grid is no longer displayed.

Fitting the curve on screen

The curve you drew might not appear as large on the screen as you would like. You can *fit* it nicely in the middle of the screen at a suitable size.

To fit the object in middle of the screen:

- Select the DISPLAY⇒ Object: Fit [f] command from the menu bar.

Deleting the curve

You will find out in the next Lesson that you will be able to further edit the curve if it is not to your liking. But for now if you don't like the curve, delete it and start again. Here is how:

To delete the curve:

- Check to see that the curve (**not** the *curve set*) you just created is still high-lighted in the **bottom** pane of object window. it is called `1. curve/Bs.` If not, click on it.

- Select the `DELETE` command from the object window pop-up menu or `OBJECT`$\Rightarrow$ `Delete [k]` from the pull-down menu if you prefer.

If you wish to input a new curve, start over again with `CURVE`$\Rightarrow$ `Design: Input [i]`. Otherwise just continue with the Tutorial.

The UNDO command

Try deleting your curve and undoing that.

If you decide that you would like to *undo* what you just did (such as deleting an object as described above), click on the `UNDO` button in the settings window (*i.e.*, `Settings`$\Rightarrow$ `UNDO`). This is vital, if for example, you delete the wrong object by mistake. You can only undo the **last** operation.

Creating a surface by rotation

You should now have a curve that looks like one half of the bottle. Now you will *rotate* it to create the actual bottle. Having come this far, it is very easy to actually do the rotation.

To make a rotational object:

1. Select the command `SURFACE`$\Rightarrow$ `Design: Rotate` from the menu window.

2.   A dialogue box with some options appears. Accept the default parameters, that is, just click OK.

This rotates the selected curve around the z axis to produce a surface: the bottle appears.
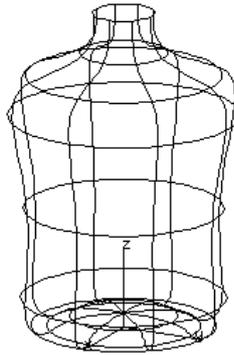
You have created a three-dimensional object!

To see the bottle *shaded*, click the Shaded button in the Settings Window.

The target object

At this point, take a new look at the object window. You will see the text

Surf/Bs/rotat

highlighted in the middle sub-window.

This is the *object hierarchy* at work. The top window (root) contains all the elements. One element (in this case the only one, bottle) may be selected. The middle window has the name of the selected element for a title, and shows all the surfaces and curve sets that the element contains. The line Surf/Bs/rotat is selected. The lowest window shows the individual curves that make up the object, in this case, the surface's "control curves".

Most DESKARTES commands require something to work on. This object is known as the *target object*. Any object specific command, *e.g.*, OBJECT⇒ Delete [k] would apply just to the target object and anything below it (belonging to it) in the object hierarchy.

We are next going to do a modelling operation to the surface's projection curve, so we need to make it the target first. This is easy to do through the object window.

To make a curve the target object:

Here you only have one element: it is already selected.

1. If it is not already selected, select the element (called bottle) containing the curve by clicking at it. Its contents appear in the middle sub-window.

2. Click on the curve set containing the curve. In this case, it is the item labelled Projections/X. This always appears in the middle sub-window.

You now know what "target object" means.

3. Click on the curve you want to make the target. In this case, it is the only item within the curve set, *i.e.*, the line labelled 1. curve/Bs in the lower sub-window.

Creating the inner surface

The curve you have drawn represents the outer surface of the bottle. The surface has no thickness at all. A real bottle is should of course have thickness, and to represent this we will design the inside of the bottle too.

There are several ways of achieving this. The simplest is to extend the curve you have already drawn so that it represents the inside as well. When doing this you need to ensure that the inside is a constant distance from the outside. This can easily be achieved using an *offset curve* as follows:

Creating an offset curve

1. Issue the command CURVE⇒ Design: Offset.

2. A dialogue box pops up which requests the offset distance. Type 3 and click OK.

3. A second curve appears and a line is added to the bottom field of the object window (labelled `2. curve/Bs`).

4. It is possible (if you drew the curve in the reverse order, starting from the top) that the offset curve appeared outside the bottle instead of inside. If this happened, select `UNDO` from the settings window and repeat steps 1 to 3, but this time type -3 as the offset distance.

If the offset curve doesn't look quite accurate, don't worry – DESKARTES has ways to make it better.

The offset curve is not connected to the original, thus leaving a gap at the top of the neck of the bottle. To fill in this gap we need to *join* the two curves.

To join two curves

1. Issue the command `CURVE⇒ Combine: Join Two`.

2. Click the mouse near the top of the curves, once for each curve, to indicate the ends to be joined. Answer `NO` to the close curve question.

The curve should remain open in the bottom!

The curves are joined to form one single curve which defines both the outside and inside of the bottle.

The surface hasn't changed yet, only the curve has. To make the surface have an inside as well, you must rotate the curve again with SURFACE⇒ Design: Rotate.

You've just learned to update a surface.
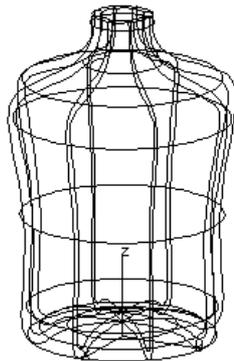
Lesson 3 : The Cap

Let's introduce a second element to show how to work with *multiple surfaces*. The second element will be a cap on top of the bottle.

To design the cap, you will learn how to edit curves. We will also introduce the concept of *(cross-)sections* which will allow you to produce surfaces which are not just circular.

Creating a second element

Since the cap for the bottle is going to be created as a separate surface we will first of all need to create a new element. Do you remember how we created the bottle element? Give the command OBJECT⇒ New [n]. Select element from the next dialogue box and type cap into the final dialogue box that appears. Click OK.

Do you remember the next step in creating an element? You must create a curve set to hold your curves. Once again you will create a projection set, defining the surface's shape from the x-direction. Give [n] again. Click at the line that says projection and click at OK. Another dialogue box pops up. You want to create an x projection set, so click at x projection and then at OK.

Inputting another curve

When drawing multiple but related surfaces you should draw the defining curves for each surface in the correct relative positions. In this case you need to ensure the cap sits on top of the bottle. Since this is an important concept DESKARTES provides tools to assist you.

Now you are ready to design the cap!

The command DISPLAY⇒ All Fit [y] is very useful. It fits all similar objects on the screen.

Select the command DISPLAY⇒ All: Fit [y]. Since you have an x projection selected, DESKARTES will fit all x projections on the screen. You will see the bottle projection on the screen, while the cap projection still remains selected. We can now input a new curve to define the cap in the correct position on top of the bottle.

This time let's input the curve without the grid – check that Settings⇒ Grid is turned to OFF.

Remember how to input a new curve? Give the command CURVE⇒ Design: Input [i] function. Position four new points with the middle mouse button, as shown below.

Exit from input mode using the Smile icon. The curve changes into a smooth one.

Fit the curve to the middle of the screen using command DISPLAY⇒ Object:
Fit [f]. Then give command DISPLAY⇒ All: Draw [t] to see the bottle
projection in the same size.
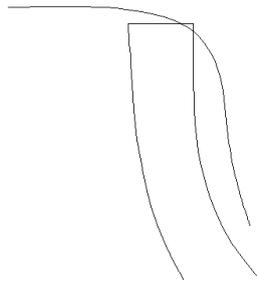
The curve doesn't look how we want! But don't worry – next you'll get a chance to
change it. No matter how careful you are at inputting a curve you will always want
to subsequently modify it's shape. The best approach to creating a curve is to use the
input mode to enter just the very basic shape, and then edit the curve to add the fine
detail. So let's go for it!

Editing a curve

Curves are edited in an edit mode, similar to the input mode used to create them. However, you can do a lot more in curve editing mode than in curve input mode. For example, you can add points anywhere in the curve, move existing points freely, relative to other points or using numeric input, and produce sharp or smooth corners.

To help you give the curve the shape you want, some of the most important techniques are described below. Go through the techniques as described, but feel free to experiment with them as much as you like.

To get into curve edit mode:

- Select the command CURVE⇒ Change: Edit [o].

Some icons appear, the control points show up on the curve, and you are ready to go.
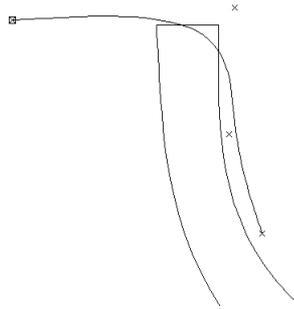
To begin with, you will only see a few icons at the top of the icon window. These represent the *general functions*, related to getting back to command mode, cancelling an operation, and selecting more specific functions.

Cancelling

Sometimes you might want to *undo* something you did while editing. Don't do this now, as you haven't done anything yet, but at any time during editing you can undo the last change made:

To undo the previous operation:

- Click on the icon that looks like a clock running backwards, or press **u**.

If you make more than just a single error, you might like to go back to what the curve looked like before you started the editing session. In such case, click at the Sorry icon, or press **q** on the keyboard. This exits from curve edit mode *without saving the changes made*. Don't do this now, just keep it in mind.

To undo all changes at once:

- Click on the Sorry icon, or press **q**.

Use this function if you feel you have completely messed up you curve, then try editing again.

To be able to use the undo function, you must not be doing something else. If you change your mind while performing a function, finish it, and then undo it.

Now you are ready to actually start editing.

Local functions
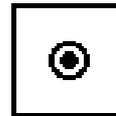
Local functions affect individual points. Such functions include things like moving, adding and deleting points, and producing or removing round corners at selected locations on the curve. You will mostly work with local functions.

To see the local functions:

- Click on the "local" icon.

Selecting a point
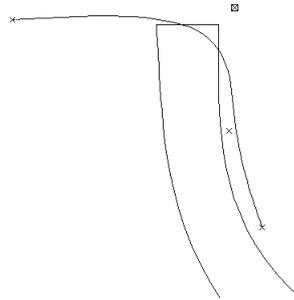
Before you can do anything to a point, you must *select* it.

To select a point:

- Click at the point with the *left* mouse button, or

- You may move to the next or previous points on the curve by pressing + or
  - on the keyboard, or by clicking at the respective icons.

The currently selected, *active point* is highlighted with a box drawn around it.

Look at the lines above the graphics window, below the menu: they are called the
message lines. One of the lines displays the exact *co-ordinates* of the active point.

!   When you start
editing a curve
the first point in
the curve is
selected for you.

Making a corner
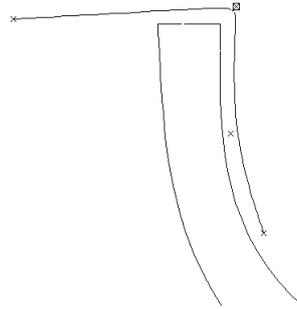
You may now like to pull the curve towards the **corner point** of the cap. Here's how:

To make a corner on your curve:

1. Select the point where you want the corner.

2. Click **c** on the keyboard, or click at the "c" icon.

Don't perform **c** on a triple point – it would just complicate things.

This adds a point on top of the selected one, creating a corner. Such a **double point** makes a *soft* corner near the point. If you perform **c** again, the point becomes **triple** and it makes a *sharp* corner through the point.
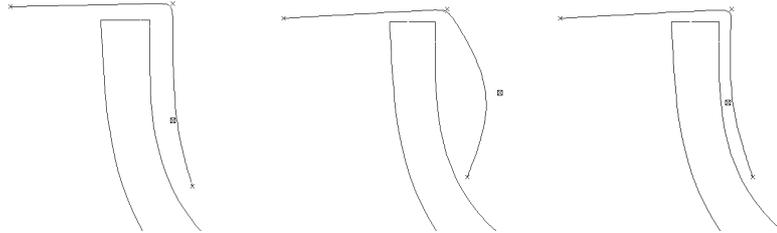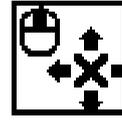
Moving a point

The most usual way to modify the curve is by moving the control points. Try it now making the cap follow the bottle neck's shape more closely.

To move a point:

1. Select the point with the *left* mouse button.

2. Press and hold the *middle* mouse button to pick up the point.

3. Move the point freely by moving the cursor. Notice how the shape of the curve is shown as you move the point.

4. Drop it in place by releasing the middle mouse button.

Inserting new points
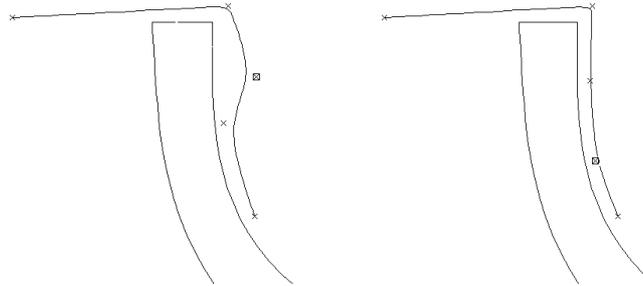
You probably found it difficult to create exactly the shape you wanted just by moving the points. To gain more interaction freedom, you may **add** new control points to the curve.

To add points to your curve:

1. Select a point next to where you wish to add the new one.

2. Click at the pencil icon or press **i** on the keyboard.

3. Click at the place you want to insert the point with the left mouse button. Move the point as desired, and click again to end the function.

Deleting a point

You may also **delete** points from the curve.

To delete a point:

1. Select it.

2. Press **d** on your keyboard or click at the eraser icon.

The selected point vanishes. You may use the undo function **u** to get it back.

Using the **d** option on a *multiple point* reduces the number of points by one each time. So to completely remove a triple point you would need to use **d** three times.

Giving a numerical value
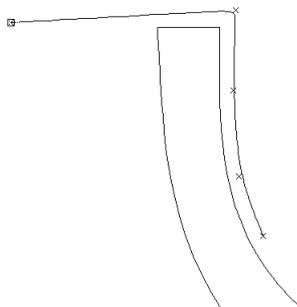
The curve's left end should be located on the vertical axis – otherwise the rotated surface will end up with a hole at the top!

One way to place the end point exactly to the axis is to define its location numerically:

To define a point numerically

1. Select the curve's left end point.

2. Use the **n** function.

3. Give the horizontal (hor) co-ordinate the value zero (0.0), and click OK.

There's an easier way to do this: use the **m** function, and click again at the active point!

Aligning a point with another
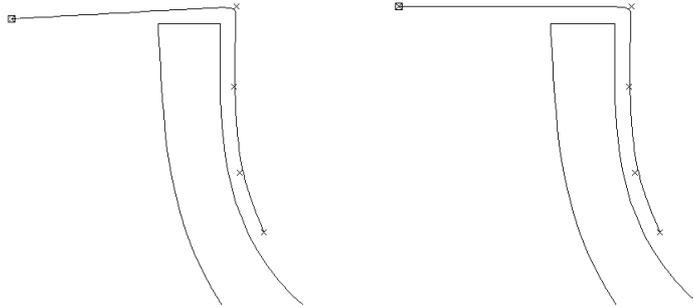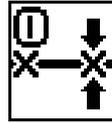
The curve should be flat at the top for the surface to be so. Use the following function:

To line up two points

1. Select the curve's left end point.

2. Use the **l** function.

3. Click on the double point next to the selected one. This is to show which is the *target point* you want aligned with the selected one. The selected point moves to in line either vertically or horizontally.

Adding a rounding
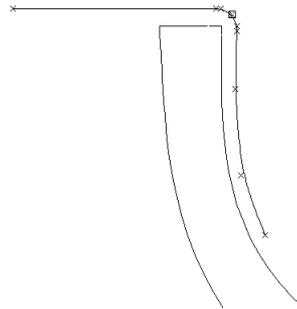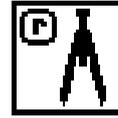
Finally, let's replace the smooth corner with a numerically defined *rounding*.

To add a rounding at a point:

1. Select the point for the rounding.

2. Press **r** on your keyboard or click at the radius icon.

3. A dialogue box appears, asking the size of the radius, and how many points you want to use for the rounding. Answer 1.0 for the radius and accept 5 for the points.

The curve changes into circular corner, a so called *fillet*, near the selected point.

Exiting curve edit mode

Save the changes you've made.

To exit curve edit mode:

• Press **w** on your keyboard, or click at the Smile icon.

*You have
learned to edit
a curve.*

The control points and icons disappear, and you are back in the normal command mode.
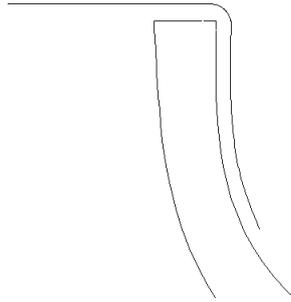
Another offset

Offset this curve to form the outer surface, using command CURVE⟹ Design: Offset and a distance of 1.0. If the curve offsets inwards then UNDO and repeat using −1.0.

Join the two curves to form one, using CURVE⟹ Combine: Join Two.
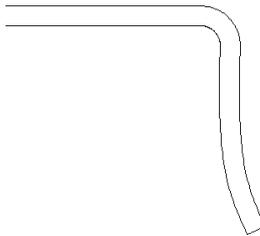
Notice that as the curves were joined, the end points became triple (sharp). Call CURVE⟹ Change: Edit [o] and make the triple points smoother using the **d** function.
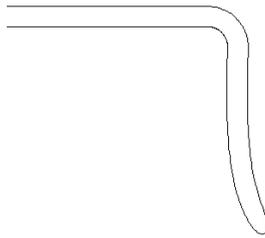
Another surface

Now make a second rotational surface.

To make a rotational object:

1. Select the command SURFACE⇒ Design: Rotate from the menu window.

2. Accept the options for vertical rotation axis and NO for centre at fix point.

The cap appears.
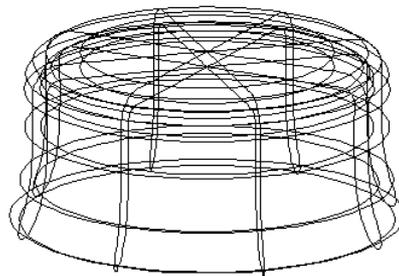
You have made another three-dimensional object!

Displaying multiple surfaces

Display the cap with the bottle surface using the command DISPLAY⇒ All: Draw [t].

Give DISPLAY⇒ All: Fit [y], to *fit* both surfaces on the screen.

To find out which surface you have selected, *blink* it using the command DISPLAY⇒ Object: Blink [l].

Try also changing the surface's *display colour*. Click on one of the colour buttons at the bottom of the settings window (at right), and see what happens.

Free-form rotational surface

What if you want something other than a circular cap? With DESKARTES it's easy! If you don't give any more information DESKARTES will assume you require a circular section. But you can define a new curve set containing a curve which defines the shape of the *cross-section* if you want. Let's do it.

To create an section set:

1. Select the command OBJECT⇒ New [n].

2. A dialogue box pops up, asking what type of object you want to create. Click at the line that says

        cross-section

   and click at OK.

The cap element now has two curve sets: Projections/X and Cross-sects. To actually define the shape of the section you need to draw a curve in the Cross-sects curve set. Rather than using the input mode to create a free form curve let's define a regular eight sided polygon, an octagon.

To create a polygon:

1. Check to see that the section set you created is still highlighted in the object window. If not, click at it to make it the target.

2. Select the menu command CURVE⟹ Design: Polygon.

3. A dialogue box appears. Answer the number of points question by typing 8. It does not matter what value you input for the radius of the polygon.

An octagon appears on the screen. To see it alone, without the surface, give the commands DISPLAY⟹ Window: Erase [e] and Object: Fit [f].
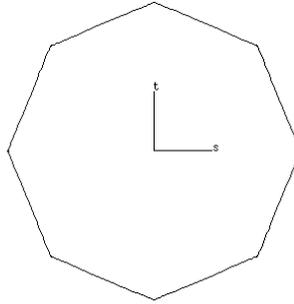
If you now re-make the surface (SURFACE⟹ Design: Rotate) DESKARTES will use the octagon as the cross-section shape instead of the default circle. Try it and see!

*You have
made a free-
form three-
dimensional
object!*
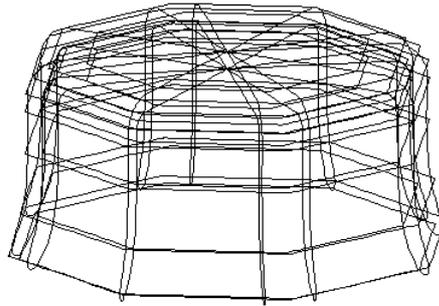
Can you see why the diameter of the polygon was not important? The x projection
defines the *size* of the cap by the distance of any point from the vertical axis. The
section simply defines the *shape*.

Lesson 4 : Viewing and Shading

You have reached the final Lesson of the Basic Part of the Tutorial.

You will learn how to

- *select objects from different elements*
- *select objects by graphical picking*
- *pan and zoom the objects*
- *view the model from different directions*
- *fast shade the model*
- *save your work*
- *quit DESKARTES.*

Selecting objects

Now that we have defined a couple of different surfaces, it would be useful to learn how to select different components of the model as the target object.

Selecting from object window

Assume you are not happy with the shape of the bottle, and you would like to edit its projection curve.

To select a curve from another element:

1. Click at the `bottle` element in the topmost pane of the object window.

2. Click at `Projections/X` in the middle pane.

3. Click at the curve object (`1. curve/Bs`) in the lowest pane.

Not too difficult.

Selecting by graphical picking

But let's try an even more convenient way, ***graphical picking!*** Assume you wish to get back to the cap's projection curve.

To pick a curve from another element:

1. You should have the bottle's projection curve selected. If not, select it through the object window, as explained above.

2. Display all the x-projection curves with DISPLAY⇒ All: Fit [y].

2. Give command GET⇒ Object: Pick [g].

3. You are now able to select any object shown on the screen by pointing at it with the mouse. *Point* at the cap's projection curve and click the *left* mouse button.

The curve gets selected. You'll see it highlighted in the object window.

Displaying objects

We have already seen how to display objects, one at a time, or several at once. Let's expand a bit on this.

Display accuracy

Look at the settings window at right, and note the Pnts and Crvs buttons. They control how ***accurately*** objects are displayed.

Move the cursor to the Pnts value and type in a new number, say, one (1). Erase the screen (shortcut [e]), and display the surfaces with [y]. Note how the surface is displayed - it happens faster, but the curves are shown less smooth.

Set the Pnts value back to the default four (4). Then type number six (6) into the Crvs field. Erase and display the surfaces – only six curves are drawn to show the surface's cross- and lengthways directions. This speeds up the displaying, too.

Actually, DESKARTES *automatically* applies lower display parameters when the objects are drawn small on screen. The above options may be used to further optimise the display speed, when you later on design your own complex models.

Auto display mode

As you select objects, they are automatically displayed. If the selected object is of a different type (a curve instead of a surface or vice-versa) than the previous one, the previous screen contents disappear and the new object is fitted on the screen.

However, if you select an element nothing is immediately displayed. The system doesn't know what type of the element's contents to display – should it be projections, surfaces or what?

There is a special option to automatically display all the surfaces within an element. For this, use double-selection: select the element another time. Erase the screen [e], and try it!

Menu display mode

Some user of DESKARTES prefer to work in this mode all of the time, to have full control of the display events to themselves.

Sometimes you might want to *prevent* the automatic displaying and erasing effect. To achieve this, change to **menu display mode** so that objects will be displayed only when commands are issued by the operator (you).

DRAW: ◇ Auto
◆ Menu
◇ None
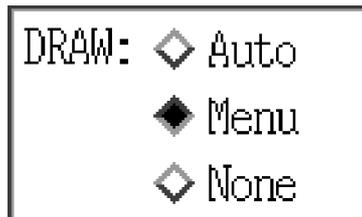
Click at the button DRAW: Menu in the settings window (at the right) and practice with the DISPLAY menu commands. Notice that selecting objects won't change the display.

No displaying

The third DRAW button `None` means that the system *won't display anything*, even if told so. This feature is sometimes useful to speed up the execution of the commands if displaying is not required, but otherwise it is rarely used.

After you have finished experimenting, click at the settings window button `DRAW: Auto` to get the system into the default displaying state.

Eye point and viewing window

You might want to look at the items you create from a different *angle*. You might also want to *zoom* in to look at a detail of the surface, or zoom out to see the larger part of the picture.

DESKARTES determines the size and position of your models on the computer screen with two things: the *eye point* and the *viewing window*. The following viewing operations affect only the display of the object, not the actual size of the geometry.

At this stage, the eye point is always "infinitely far": there is no perspective. The eye point defines the viewing direction, and the window describes the where to look at and how large the "zoom" is.

Before you continue, have a surface selected as target and give the command `DISPLAY⇒ All: Fit [y]` to view both the surfaces.

Panning

You can change the viewing window by *panning*. This means that you change the part of the scene that the camera looks at.

You now know all about selecting and displaying objects!
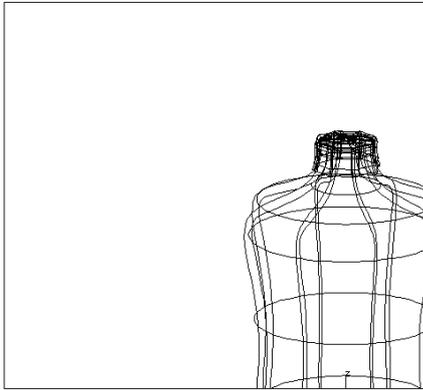
1. Select the command DISPLAY⇒ Window: Pan [x].

Use the keyboard
shortcut [x].

2. Press (and hold) the left mouse button to show a point within the graphics window.

3. Move the mouse, and a line appears. It shows where the selected point will move.

   Release the mouse button where you want the first chosen point to move.

The objects move on the screen. Experiment a while with this.

Zooming

Another way of changing the viewing window is by *zooming*. This makes the objects on the screen look smaller or larger.
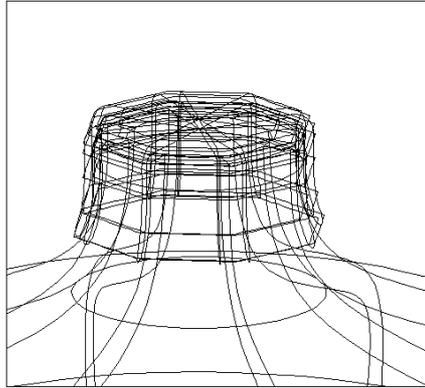
With the zoom command, the different mouse buttons change the view in different ways.

To zoom:

1. Select the command DISPLAY⇒ Window: Zoom [z].

2. Take a look at the message lines above the graphics window? With zooming, it reads: draw window (LEFT)/zoom closer (MID)/ zoom away (RIGHT)/pan (key). This describes the way the mouse buttons change the view.

3. Press the *left* mouse button at the centre point of the desired window and hold the button down.

   Still holding the mouse button, move the cursor upwards: a box appears. It changes size according to the location of the cursor.

   When the box encompasses everything you want to see, release the mouse button.

4. Press [z] (shortcut for zooming).

5. Click the *right* mouse button: you zoom out. The objects become smaller.

6. Press [z] again.

7. Click the *middle* mouse button: you zoom in. The objects become bigger.

8. Finally, there's an "extra" option with the zoom command: if you click at *any key on the keyboard* after issuing the command, you will be able to pan instead of zooming.

Experiment a while with the different zooming options.

Changing the eye point

Panning and zooming did not change the viewing direction. Now let's try how to do that.
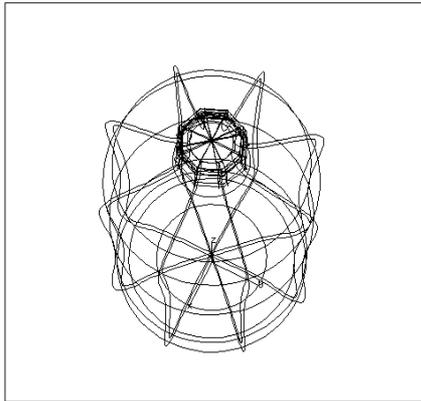
To move the eye point:

1. Display all surfaces `[y]`.

2. Select the command `DISPLAY`⇒ `View: Eye Point [v]`.

   A box appears around the bottle.

3. Point at the box and press the left mouse button.

4. Move the mouse sideways. You will see the box rotate horizontally.

5. Move the mouse up and down. The box rotates vertically.

6. Release the mouse button, when you are happy with the view.

7. Repeat the steps 2 – 6 as many times as you like.

8. When you are happy with your new eye point, press the **w** key on the keyboard. The new eye point is now selected for all 3D display operations.

Shading with PreView

DeskArtes gives you the option of shading and rotating the bottle in *real time* using the **GL graphics** functionality. You can quickly see this by choosing SHADED from the right hand settings window. Alternatively, you can use the slightly better quality shading available in a separate window from the RENDER menu.
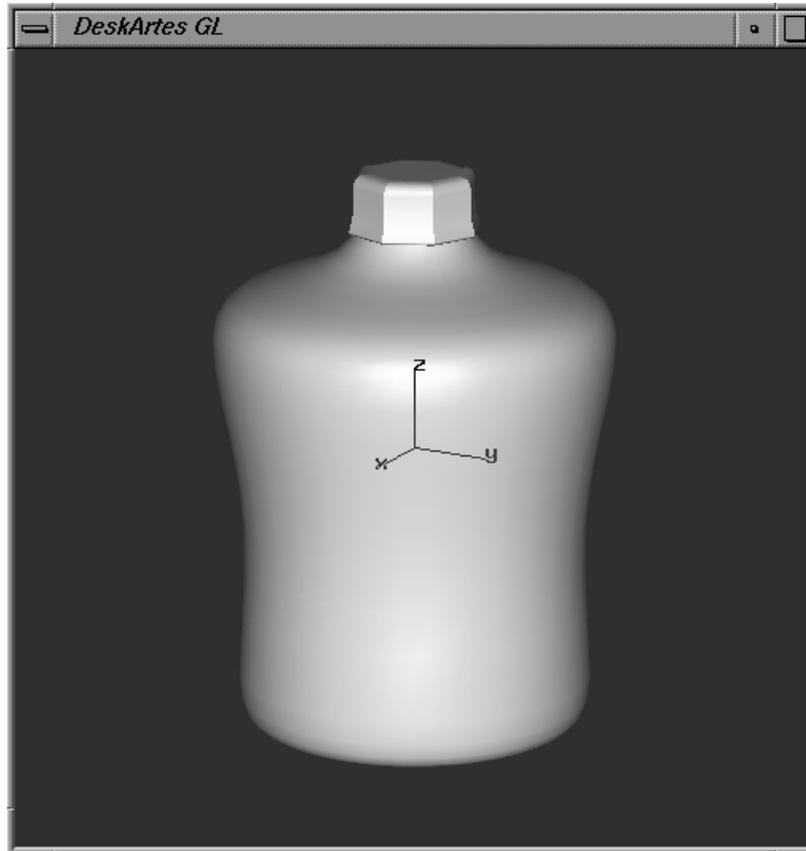
To shade the bottle:

1. Display the bottle and cap surfaces [y]. *What is currently on the screen defines what will be shaded.*

2. Select the command RENDER⇒ GL Window: Shaded View.

3. A window called the GL Window appears, attached with the cursor. Place it somewhere in the upper left hand corner of the screen.

4. Wait a short while, as the bottle appears shaded in the GL window.

5. You may enlarge the GL window to cover the whole screen. Click at the larger rectangle at the GL window's upper right hand corner.

6. A menu of the **GL Window commands** appears as you press the *right* mouse button within the GL window.

   Some menu items have a **sub-menu**. The sub-menu commands may be selected as you move the cursor to the right end of the chosen menu item.

   Always **end the GL command** by clicking the *right mouse button* again.

7. Try the command `Move Camera`. Move the mouse, and the object rotates —just as with command `DISPLAY`⇒ `View: Eye Point [v]`, but now in real time shading!

   On very large models, the **rotation speed** won't really be real time. Select the command `Move Mode`⇒ `Box` to make the rotations more fluent.

8. Try `Move Camera` again. Now hold the *middle* mouse button down, and move the mouse up and down to change the **perspective** of the image.

9. If you get lost, by zooming too close for instance, you may always **recover** with the command `Lost in Space`!

10. Try the command `Move Light`. Its interaction is equal to `Move Camera`, but now the **light point** moves around the model.

11. Try automatically **spinning** the saucer around with the GL command `Auto Rotation` ⇒ `Infinite Rotation`. Move the mouse to see different rotation speeds and directions.

12. Experiment by repeating the steps 6 - 8 as long as you like. You may try the other functions, as well (see the Reference Manual for details).

13. End the real-time shading with the GL command `Done`. The GL window disappears from the screen.

You now know how to shade your models!

Fun, isn't it! `RENDER` shading is fun but it is much more than that. `RENDER` shading is a very useful *surface analysis* tool. You can use it to check that the shape of the surfaces you have created are exactly what you required. Because `RENDER`

shading is so quick it is something that you can use regularly as you progress through the design process.

Yet, this is the lowest level of visualisation available within DESKARTES. Much more realistic pictures of your design can be generated using the RENDER⇒ GL Window:Camera View mode, with interactively defined colours, materials and light points. Ultimately, you would use the ExTrace system to render the bottle in true glass, textured with painted graphics, reflecting the natural surroundings defined around it.

Trying out ExTrace

So let's have a go a it! See what you can do with *ray tracing*. You'll also get a hang of *material editing*.

All details and many more options for what happens next will be explained thoroughly in the Visualisation Part of this Tutorial. So just relax, and follow the step-by step instructions now.

To use the material palette:

1. Give the command SCENE⇒ Material: Palette.

   A large window (the material palette) shows up.

2. Click at the name "glass" under the MATERIALS title, and LOAD it in the palette.

3. Click at the button SHOW under the TESTIMAGE window. You'll see how the chosen material looks like on sphere and a checker table (floor).

4. Select the bottle surface (or element) using the object window selections.

   Then click at the ASSIGN button in the middle of the material palette window to assign the selected material to the bottle.

5. Click at the box labelled "floor" in the long horizontal field in the middle.

6. Click with the *left* mouse button on any colour you see in the upper left corner.

7. Select the "glass" material. Click SHOW again to see in the test image how the checker squares under the ball have new colours.

8. Repeat steps 5-7 to change the second floor colour ("floor2"), and the "background" colour, as well.

8. Exit the material palette with OK at bottom left.

Now you have the bottle assigned with the proper material, glass. The cap is still of the default material. You've also specified what the surroundings will look like. By default, you only have one light point defined.

All that remains is to create the picture.

You've worked with materials and colours!

To ray trace:

1. Display [y] the cap and the bottle. View [v] them from the direction you want to have ray traced.

2. Select command EXTRACE⇒ Start/Update. Accept the parameter queries as they are with OK.

3. A rectangle shows up on the screen. It represents the size of the ExTrace window.

   Position the window in the upper left corner of the screen. Click the left mouse button to drop the window to its place.

4. Wait a few seconds, and the ray tracing starts. First you'll see just a rough picture, but it is quickly refined to finer detail.

5. The floor is missing! Move the cursor into the ExTrace window, and interrupt the computation by clicking the Stop button.

6. Give command EXTRACE⇒ Insert: Floor. In the following dialogue boxes, tell that you wish to have a default sized floor of

`stripes/squares`, consisting `checkerboard` pattern, with 16 (times 16) squares in it.

7. ExTrace waits in case you wish to give it more specifications for the scene. As you don't, give command EXTRACE$\Rightarrow$ `Start/Update` to see the picture anew.

8. Have a coffee break while the picture refines, you've deserved it!

   ... If the image isn't ready when you come interrupt the computation as described above.

9. To exit ExTrace, give command EXTRACE$\Rightarrow$ `Done.` Later you'll learn how to compute the picture in the desired size, accuracy and so on, but for now, just accept the parameter queries as they are.

Saving your work

Before you end the modelling session, you must *save your work*. The first thing you did at the start of the Tutorial was to create a model directory for yourself. Now you will save your model in it.

To save your work:

1. Click at the *middle* mouse button in the graphics window (or use command SYSTEM⇒ Show Files). The file window pops up.

2. Display the pop-up menu in the middle sub-window using the *middle* mouse button. Note that the commands are different from the ones in the left sub-window pop-up menu. Select the FILE: WRITE command.

3. DESKARTES asks you for the type of file you want to write. Accept the option model (geom_) and click at OK.

4. Now, DESKARTES prompts you for a name for your model. Type and click at OK.

Your model was now written in a file named geom_. You can see the name in the middle field of the file window.

You have saved your work.

Ending a modelling session

Now you have completed a modelling session and you may wish to exit DESKARTES.

To exit DESKARTES:

It is not good practice to exit DESKARTES without first saving your work if you want to keep it.

1. Select the command SYSTEM⇒ Quit [q].

2. DESKARTES asks if you really want to quit. Click at YES to accept.

Congratulations! You have completed the Basics Part of the Tutorial, ready to move on to more interesting work.

You know the Basics now!

Even if you still feel uncertain of your skills, don't worry. The next Tutorial Part begins with quite similar interaction to what was introduced here, providing you a further chance to practice with the DESKARTES basics.

PART II: MODELLING PRINCIPLES

The following six Lessons give the step-by-step description of the operations you need to perform to design a moderately complex model, namely, a coffee pot.
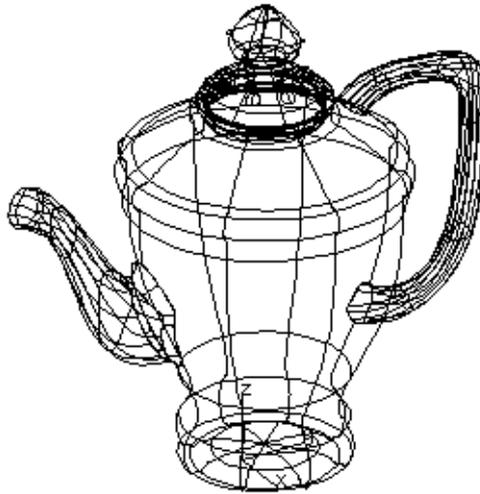
The example demonstrates most of the modelling features of DESKARTES. You might wish to repeat some of the operations within a Lesson. This will allow you to express your own design characteristics. Please feel free to do so. However, we recommend that you first follow the Tutorial descriptions quite closely before you begin to experiment.

Lesson 5 : The Coffee Pot Body

In this Lesson, you will review the simple curve and surface creation techniques introduced in the first Tutorial Part, and learn some new techniques to modify curves. You will design the main body of the coffee pot. This will form the start of a continuing modelling exercise that will be used for the rest of the DESKARTES Tutorial.

By now, you should be familiar with the basic DESKARTES interaction techniques, and should be able to concentrate on the actual modelling instead of how to use the menus and buttons.

Resuming work

Start DESKARTES.

Last time, you created a model directory for your bottle, as well as a model file. Instead of creating a new model directory now, you will use the one you have already created.

In the left sub-window of the file window, you see a list of the existing DESKARTES *directories*.

Scrolling

It is possible that there are more directories than can fit in the window. This means that you will have to *scroll* through the sub-window. Scrolling means moving text or a picture within a window.

If all the directories fit into the sub-window, the scroll bar is entirely filled by an embossed rectangle, and you can't scroll. In that case, skip this bit. Return here if you need to scroll later.

There are several ways you can scroll the sub-window.

The *scroll bar* is situated to the right of the sub-window. It looks like a thin, tall rectangle with arrows at either end and a smaller, embossed rectangle within the thin one.

- Click with *left* mouse button at the lower arrow to move the text within the window up one line. A new line is displayed at the bottom.

- Click at the upper arrow to move the text back down. The top line shows again.

- Press the *left* mouse button on the lower arrow to move the text rapidly up, until you reach the bottom of the list.

- Drag the small embossed rectangle within the scroll bar up or down.

Since we want to create a new model in the same directory that we used before we need to select the directory. Do this by clicking on the name in the left hand list that you created in Lesson 1 (`name_tutorial`). When you have done this, you should see the name of the bottle model file (`geom_`) appear in the middle window. The work we do now will be stored in the same directory as the bottle.

As you have selected your working directory, hide the file window with the `OK` button and begin work.

Creating the coffee pot

You will create the body of the coffee pot by rotation, like this:

Begin as you did with the bottle at the beginning of the Tutorial.

To initialise the body element:

1. Create [n] an element named `body`.

2. Create an x projection set. However, instead of giving [n] again, this time try a specialised command: GET⇒ Object: Projection [p]. You'll get the projection directly, without having to select parameters!

3. Use CURVE⇒ Design: Input [i] to enter the outer curve, similar to that below.

4. When ready, exit the input mode (**w**). The curve turns into a smooth one.

Editing a curve

Next, you will edit the curve. You'll be introduced to a couple of new editing functions on the way.

Start the edit mode, and take a look at the global functions.

Global functions

Global functions affect the curve as a whole or several points at once, or control the way the curve is displayed on the screen.

To see the global icons:

• Click at the "globe" icon.

At this point, you will use a couple of global functions that alter the way the curve is displayed on the screen.

Zooming and panning

Note that the menu commands, like DISPLAY⇒ Window: Zoom [z], are not available when you enter an edit mode. However, some of the display functions are included in the editing functions. Zooming is one of them.

Experiment a while with this:

To zoom in edit mode:

1. Click at the "z" icon or press **z** on the keyboard.

2. You may zoom using the different mouse buttons, just as with command DISPLAY⇒ Window: Zoom [z].

There is no special function for panning, but remember you can do it with the zooming function:

To pan the image:

1. Click at the "z" icon or press **z** on the keyboard.

2. Click at *any key on the keyboard* (not a mouse button).

3. Press and hold a left mouse button down. Move the mouse, and release the mouse button at the new location where you wish to have the image move.

If you wish to get back to the exact window size you started from, you have the following function available:

To zoom to the initial size:

*   Click at the "Z" icon or press **z** on the keyboard.

Refreshing the screen

As you move the points during editing, the old parts may not always be properly erased, and you might have some extra dots remaining on the screen. That won't be the case just now, but here's how to get over it anyway:

To refresh the screen:

    1. Click at the "f" icon or press **f** on the keyboard.

Now let's get to actual modelling. You may keep the global icons on the screen, or hide them by clicking the "globe" icon again, just as you like.

You now know the editing display functions.
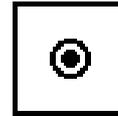
Local functions

Now use the local editing functions, as you've already learned with the cap model. Before you start, click on the "local" icon to see the functions.

Remember always to select the active point first before executing the function.

If (when) you make mistakes, you can always cancel with the **u** function.

Review on local editing

Create some corners to the curve using the **c** function around the lid opening the foot and the rightmost point (use double points not triple).

Align the curve around the lid opening parts with **l** to form right angled corners.
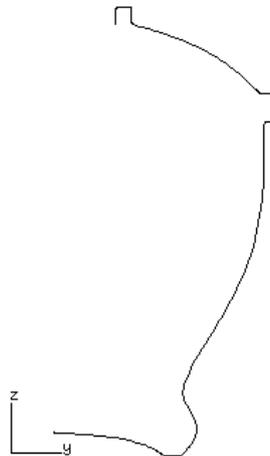
Move (*middle*), insert (**i**) and delete (**d**) the points just as you wish to achieve the shape shown above.

Some new functions
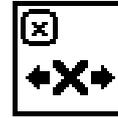
Axial moving

If you have already aligned a couple of points, but still wish to move them, there is a way to do it while keeping them aligned. Try this:

To move in axial directions:

- Use the function **x** to move the point. The movement becomes restricted to the direction in which you first move the mouse.

Moving multiple points

You may want to move a group of points. This is achieved by first making a *multiple point selection*, then using the usual moving functions.

To move multiple points:

1. Click on the first point of the group to be moved with the *left* mouse button. Try moving the points around the foot as a group

2. Click on the last point to be moved with the *right* mouse button. It is highlighted with a double box. This makes a multiple selection of all the points between the first and last points.
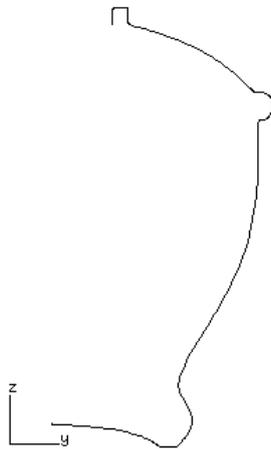
3. Press and hold the *middle* mouse button to pick up the points.

4. Move the points freely by moving the cursor. Drop them in place by releasing the middle mouse button.

6. Try multiple selection with the **x** function, too.

Play with the editing functions as long as you like. You may take the liberty to make the shape your own, but don't get too wild! We'll use this model for the remaining of this Tutorial, and very different shapes than the one below might not work with the tutorial instructions.

You've learned many useful editing functions.

Creating a rotational surface

Rotate the curve with SURFACE⇒ Design: Rotate like you did with the bottle. This time use the options for vertical axis and Centre at fix point NO.
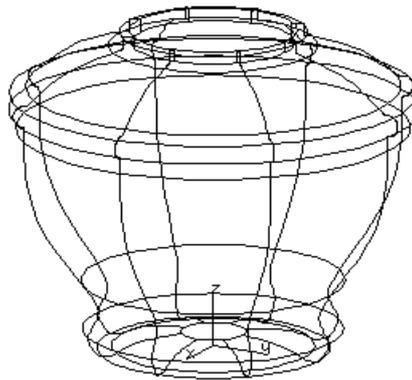
OOPS! You have created an incorrect coffee pot body; it has a hole in the bottom!

The fix point

The result of the previous surface rotation is not what was intended! The body has a large hole through the middle! This is because the body was rotated about the

The fix point defines the origin of an object. It affects many commands.

central z-axis and we choose not to draw the curve touching the vertical axis to illustrate this point. To avoid this we need to use a feature of DESKARTES called the *fix point* that determines where the origin for an object is.

The fix point is specified for *each object separately*. It can be moved around at any time to suit the situation. In this case, to get the correct result when we rotate the surface the fix point, which defines the axis of rotation, should be located on the left hand bottom end of the defined curve. Let's move it now.

To position the fix point:

1. Make the curve the target object. It is labelled as `1. curve/Bs` in the object window.

2. Select the `TRANSFORM⇒ Fix Point [0]` command.
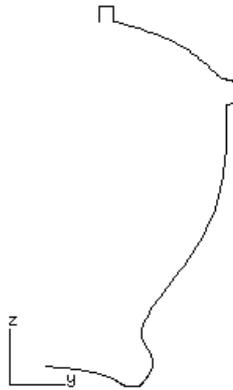
2. Click with the *middle* mouse button on the box (handle) that appears on the bottom left of the curve. This places the fix point to the nearest handle.

Rotate the curve again with SURFACE⇒ Design: Rotate this time using the
options for horizontal axis and centre at fix point YES.

**That's better!
You have
created the
correct coffee
pot body.**
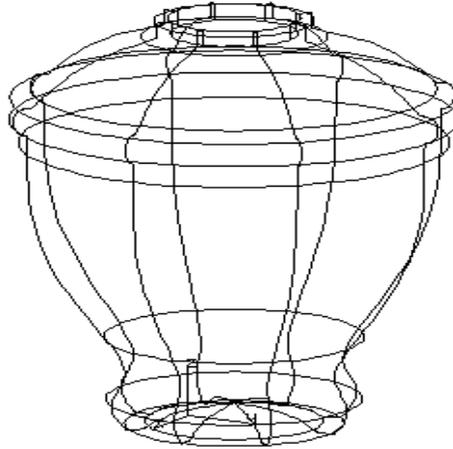
You may be thinking that we could have achieved the same result by moving the
curve to the centre-line - the z axis. You would be right. In fact in this case this
would be the best way of achieving the desired result, but this would not always be
possible so its good to find an alternative way as we have just shown here.

Transforming curves

It would be useful to see the projection curves representing *both* sides of the body.
The whole side view would not only show the shape better, but also helps us in
creating the other parts of the coffee pot later on.

Mirroring an object

The other half can easily be created by taking a *copy* of the existing curve and
mirroring it in the horizontal direction.

To copy and mirror a curve:

 1. Select the projection curve (1. curve/Bs in the object window).

2. Select OBJECT⇒ Copy [j]. This will duplicate the curve.

There will now be two names in the bottom field of the object window
called 1. curve/Bs and 2. curve/Bs. The second (copied) curve is
selected.

3. Select TRANSFORM⇒ Mirror [m].

4. Select the option to mirror horizontally.

The fix point
defines the origin
for mirroring an
object.

5. The curve is mirrored. Display the curves with [y].
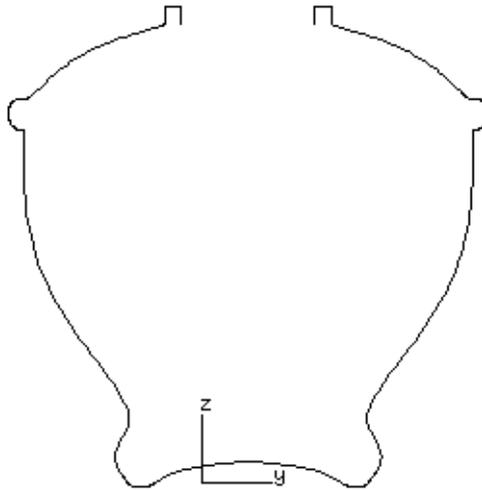
Moving and scaling

Now that you see the complete coffee pot body profile from the side, you might want
to modify the curves. Let's see how to scale both curves:

To scale the curves:

1. Select the line `Projections/X` in the middle field of the object window.

2. Give command TRANSFORM⇒ `Fix Point Copy [9]`. This copies the last used fix point (the one you used for mirroring) to be the fix point of the target object (the whole projection set).

3. Select TRANSFORM⇒ `Scale [2]`.

4. Press and hold the *left* mouse button at the middle of the curves. Move the mouse, and the curve follows the cursor, scaling uniformly in both directions until you release the button.

   Notice that as the curve grows and shrinks it does so about the fix point, at the centre of the two curves.
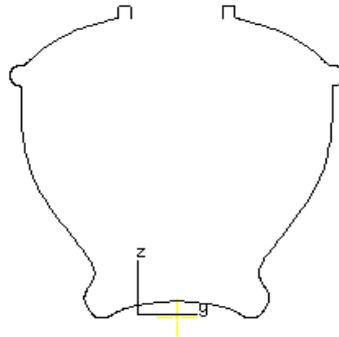
5. Repeat command TRANSFORM⇒ `Scale [2]`, but now press the *middle* mouse button and move the mouse upwards. The curve follows the cursor until you release the button, but this time is constrained to only scale vertically.

   When you use the middle mouse button, DESKARTES locks the curve to scale in the direction of your first mouse movement.

You will transform both curves within the set.

The fix point defines the centre for scaling.
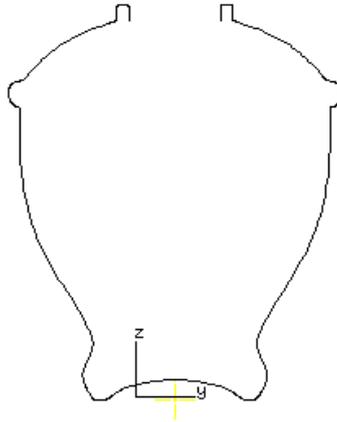
Try moving the curves, too:

To move a curve:

1. Have `Projections/X` selected in the object window.

2. Select `TRANSFORM⇒ Move [1].`

The fix point
moves, too!

3. Press and hold the *left* mouse button and move the mouse. The curve
   follows the cursor until you release the button.

Just like scaling!

4. Give `TRANSFORM⇒ Move [1]` again. Press and hold the *middle* mouse
   button and move the mouse upwards. Since you are using the middle
   button, the curve follows the cursor again but this time it is constrained to
   only move vertically. Release the mouse button to drop the curve.

Numeric transformations

Another way to move or scale your curve is by numeric values. This is easily
achieved. The description here is for scaling but the technique works the same for
all transformation commands.

To scale a curve numerically:

1. Select the curves you want to transform.

2. Select the appropriate transform command, for example
   TRANSFORM⇒ Scale [2].

3. Press *any key on the keyboard* to indicate you want to enter a numeric
   transformation. A dialogue box appears to allow you to enter numeric
   values for the transformation.

4. Enter the scaling values, *e.g.*, 1.0 and 2.0. Click on OK to exit the dialogue
   box.

Try that, and use the UNDO function to return the curve to the original position
after each attempt.

Before you continue, you should have the curve scaled to the desired shape, as
below.
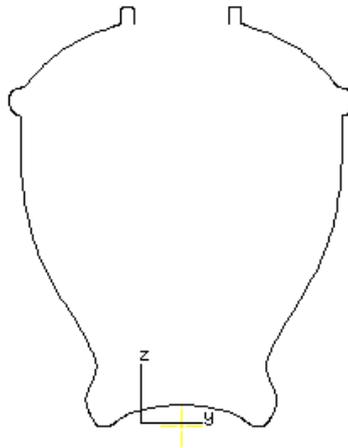
You have learned to transform curves!

Updating the surface

The previous transformations changed just the curves, not the surface. You will need to rotate the surface again so that it accurately reflects the shape of the curves.

Give command SURFACE⇒ Design: Rotate, with parameters vertical axis and centre at fixpoint YES.
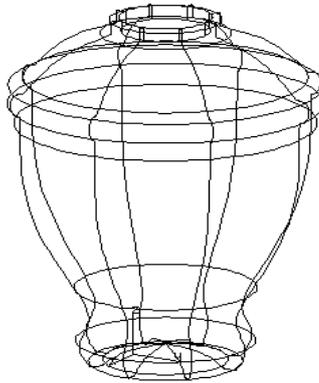
Saving your work

Remember you learnt in the first Part of the Tutorial that before you end a modelling session, you must *save your work*. This is an opportune time to save completed work. Here is a reminder of how to do this.

To save your work:

1. Click at the middle button in the graphics window. The file window pops up.

2. Display the pop-up menu in the middle sub-window. Note that the commands are different from the ones in the left sub-window pop-up menu. Select the FILE: WRITE command.

3. DESKARTES asks you for the type of file you want to write. Select model (geom_) and click at OK.

4. Now, DESKARTES prompts you for a name for your model. Type coffee and click at OK.

Your model is written in a file named geom_coffee. You can see the name in the middle field of the file window.

Finally, end the modelling session with command SYSTEM⇒ Quit [q]. Do this in any case, even if you wish to continue modelling right away – we will practice resuming work in the next Lesson.

You've designed the coffee pot body.

Lesson 6 : Getting a Handle on it!

The surfaces you have created so far are by DeskArtes standards very simple surfaces! You will now make a handle for the coffee pot using a technique capable of producing surfaces that are more complex: building a surface. It is worthwhile concentrating hard on this Lesson as this is the most commonly used technique for creating surfaces in DeskArtes.

Resuming work

You have previously created a model directory for your model, as well as a model file. Now, you will *resume work* on the coffee pot model.

Start DeskArtes the same way as before.

Reading a model file

Your model is stored in a model file, which is in your model directory. Therefore, you will want to *open* it.

To open a model file:

1. Display the file window, if it is not already displayed. Locate your model directory in the left sub-window and select it by clicking at it.

2. The middle sub-window shows the contents of your directory. Select your model file (`geom_coffee`).

3. Select the command `FILE: READ` in the middle sub-window pop-up menu.

Now you have your model in DeskArtes again and may hide the file window with the `OK` button and begin work.

Projection curves for building

The surface building command creates a surface that follows the shape of the pro-jection curves from the projection direction. In other words, the projection curves define the *side view* of the surface. You'll create the curves very much like the two curves you defined for the rotation, but now you will be able to edit the curves independently, as well.

Input the projection curves in the right place. That way you won't have to use the transformation commands.
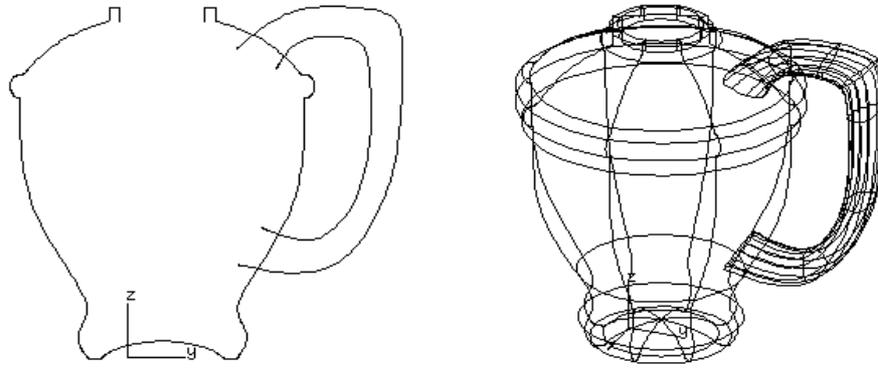
Creating the projection curves

You will use two projection curves to define the handle. They define its outer and inner shapes from the chosen view (x direction).

Make a projection curve for the handle:

1. Make a new element and label it handle (use OBJECT⇒ New - remember?).

2. Make an x-projection set (OBJECT⇒ New).

3. Display the projection curves of the body. Remember this is achieved by the DISPLAY⇒ All: Fit [y] command.

4. Zoom [z]/*right* button and pan [x] to have more space for your drawing.

5. Input and edit the outer curve of the handle as shown below.

The end of the curve should protrude through the inside of the body.
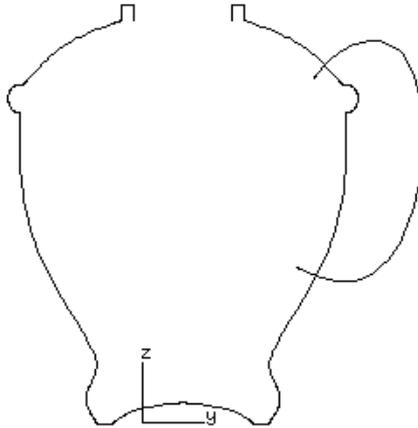
For building a surface, two projection curves are normally required. An easy way to create the other curve is to *offset* the outer curve we have already to form the inside of the handle. We have already used the offset command to create the inner surface of the bottle - remember?

Creating an offset curve

1. Issue the command CURVE⟹ Design: Offset.

2. A dialogue box pops up which requests the offset distance. Type 8 and click OK.

3. A second curve appears and a line is added to the bottom field of the object window (labelled 2. curve/Bs).

4. It is possible, depending on the direction you drew the that the offset curve appeared outside the handle instead of inside. If this happened select UNDO from the settings window and repeat steps 1 to 3, but this time type -8 as the offset distance.
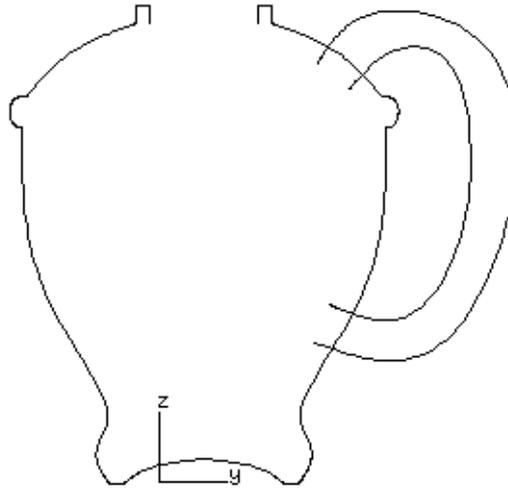
Editing the projection curves

Now we have the two sides of the handle. But the shape doesn't look "handy"! Let's edit it now.

Before editing, let us note that there are some rules to be obeyed when building a surface. One of these rules is that the *two projection curves must share an equal number of control points*. If we alter the shape of one of the projection curves by adding or removing points, we must add/remove similar points from *both* projection curves.

Edit the curve now by moving points to thicken it up as it meets the body.
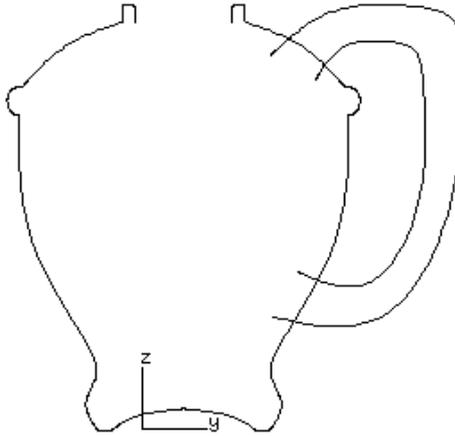
A section curve

The surface building command also needs to know what the *cross-section* of the surface looks like. Surface cross-sections are described by *section curves*, contained within a section set.

Remember we used a section curve for the bottle cap in Lesson 3 for the surface rotate command. In that case sections were optional, for building surfaces they are always required. At this stage, you will use only one section curve for the handle. Here is a reminder of the procedure for creating a section curve.

Creating a section set

Create a section set:

- Perform OBJECT⇒ New [n] and select cross-section from the dialogue box.

Or

- Use the faster alternative, GET⇒ Object: Cross Section [c]!

Making the section curve

Create a circle as the basis for the section curve.

To create a circle:

1. Select the command CURVE⇒ Design: Circle.

2. Type 10 for the radius of the circle, and 12 for the number of points to use. Click OK.

The circle appears around the origin of the co-ordinate system.

Editing the section curve

You won't want a circular cross-section for your handle. Fit [f] the circle to the middle of the screen, and enter the curve editing mode [o].
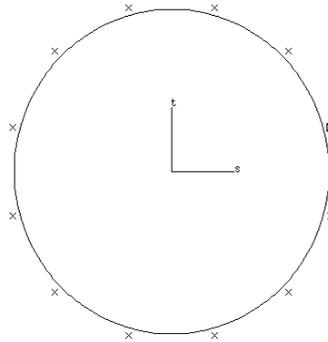
You will want to ensure that the section is *symmetrical* about the horizontal centre line - there are some useful functions in curve editing to help you to achieve this. Therefore, first edit just the upper half of the curve into the desired shape.
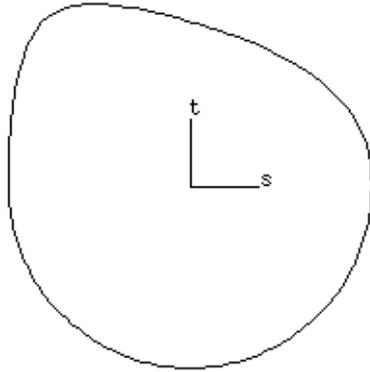
Now look at the local editing functions.
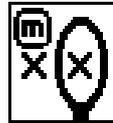
Mirroring a point

The **m** function mirrors a point relative to another point. Use it now.

The **m** function would mirror horizontally, if appropriate.

To mirror a point with another:

1. Select one of the points on the bottom of the curve.

2. Select the mirror function **m**.

3. Click near the opposite point on the top of the curve. The first, **selected point** moves directly opposite the second point.

4. Repeat steps 1-3 for all the points you wish to mirror.

You've designed the handle's cross-section.
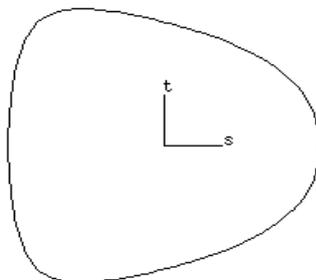
Move and mirror the points until you come up with a satisfactory shape. When ready with the changes, exit the edit mode with **w**.

Building the handle

As you have finished the projection curves and the section curve, you will want to build the surface. Easy! Just select the command BUILD⇒ Create: Surface [b] and the handle appears.
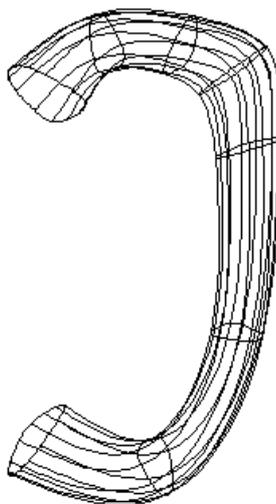
OOPS! The section points in the wrong direction. The handle tapers outwards.

The handle appears but the section may be the wrong way around, as above. The handle should taper towards the body not away! Read through the following anyway so you know how to overcome it now or in the future.

Build parameters

You could get over the problem by rotating the section curve by 180 degrees. But often you would want to keep the section curve in the orientation you defined it. Therefore, you may tell DESKARTES to rotate the curve only *when building*, while the actual curve stays in its place.

The command BUILD⇒ Set: Build Parameters controls various ways *how* the surface is built. Section orientation on the surface is one of them. The build parameters can be defined separately for each element.

Section orientation

To change the section rotation:

1. Give command BUILD⇒ Set: Build Parameters.

2. Tell DESKARTES to use section rotation of 180 degrees when building the surface.

Build the surface again with BUILD⇒ Create Surface [b].

This is better!
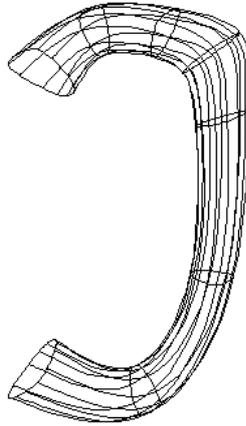
?   Problems

If you did not get the handle computed properly, the most probable cause is that you have broken one of the rules for building. Read through the following check list.

Remember each projection curve must have the same number of points? Click on each of the projection curves in turn at the bottom object window pane, or select by graphic picking GET⇒ Object: Pick [g]. The number of points is then shown in the message line at the top of the screen. If they are different, edit the curves and add/delete points until they are equal.

Or perhaps the building command did something, but the resulting surface looks funny? Check to see if you really have *two* projection curves defined. Or did you accidentally give the wrong surface creation command - perhaps SURFACE⇒ Rotate instead of BUILD⇒ Create Surface [b]?

To build a surface you must have a section curve. On the other hand, there may not be more than two projection curves. Perhaps you have accidentally created the section curve in the projection set? If so, try the following.

To move a curve into another curve set:

1. Select the section curve in the projection set.

2. Give command OBJECT⇒ Cut/Paste.

3. Select (or create) the section set.

4. Give command OBJECT⇒ Cut/Paste again. The section curve moves to the chosen curve set.

Finally, if you don't have a section curve defined at all, you may have accidentally deleted it. Try defining it again.

Orthogonal views

To check that the handle surface is really the desired shape, try the *eye point control buttons* in the settings window.

The x, y, z, and 3D views:

1. Select the handle surface.

2. Click at the button labelled X at the bottom of the settings window. The eye point moves to the x-axis.

3. Try the other two axial views from the buttons: Y and Z.

4. When you have finished experimenting, click at the 3D button.

Section scaling in one direction

As you look at the surface from different directions you will see that the handle indeed thickens as it meets the body, reflecting the shape of the x projection curves. However, as the handle bulges when seen from the x direction, it by default also bulges when seen from the y direction.
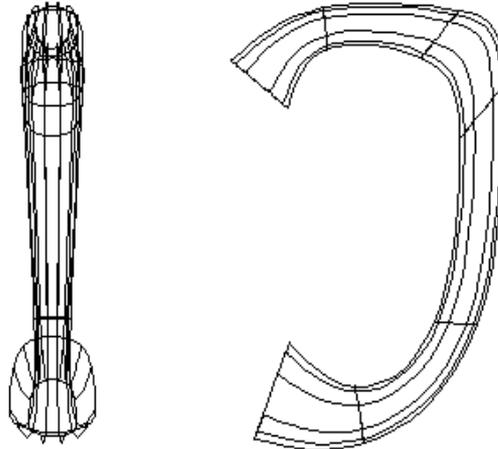
In other words, at all points, the cross-section of the handle is the same *shape* and *proportions* as the section curve you drew. It has been *scaled* up in both directions so that it will fit between the two projection curves.

This could be just what you wanted, but there is one option of the build command that you might like to investigate here. Change one of the controls for building.

To build the surface with constant width:

1. Select the command BUILD⇒ Set: Build Parameters.

2. Select section scaling in one direction from the dialogue box that pops up. Click OK.

3. Build [b] the surface again.
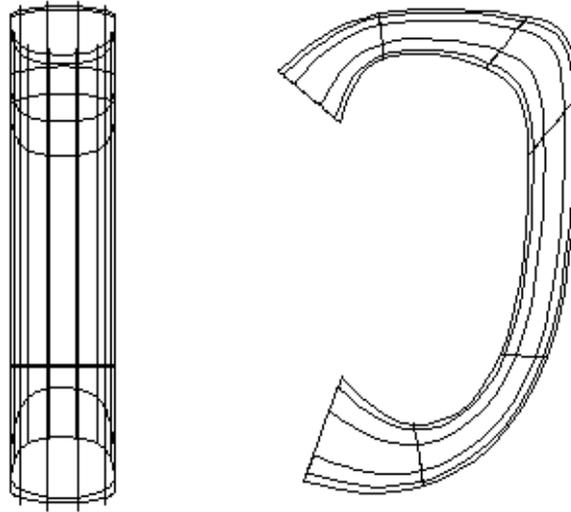
The handle appears. Can you see the difference? It is particularly evident if you look at the surface from the y direction. The sides of the handle when viewed from this direction are vertical. No bulges!

The width of the handle is now exactly the same as the width of the original section curve all the way up. If you consider the handle to be too narrow or too wide for your taste, scale the section curve accordingly and rebuild the surface.

Revert to the 3D view and draw the handle with the base surface [y]. You might also want to view the model from different directions with DISPLAY⇒ View Eye Point [v]. See Lesson 4 if you don't remember how.
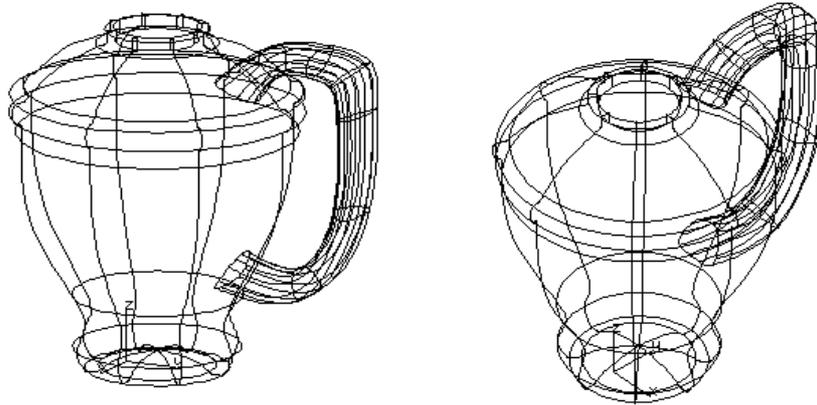
Saving the work

We will save the work in file, just in case we need to come back to this point.

Save your work:

1. Show the file window.

2. Perform FILE: WRITE.

3. DeskArtes asks you for the type of file you want to write. Accept model (geom_).

4. DeskArtes prompts you with a name for your model. Accept the previous file name coffee and click OK.

5. DeskArtes points out that a file named geom_coffee already exists, and asks if you want to *overwrite* it. Click YES and OK.

Overwriting a file means the old contents are wiped out.

Lesson 7 : The Spout

In this Lesson, you will add a spout to the coffee pot. The shape of the spout is very free-form.

Free-form shapes are often very difficult to achieve on a computer modelling system, but DESKARTES provides facilities to make such a shape relatively simple to create. You will learn a lot more about the building method.

You will remember we used the surface build command for the construction of the handle. We built it by defining a pair of projection curves that described the outline or silhouette of the surface from a projection direction. The cross-section of the handle was defined by a single section curve. DESKARTES then generated the shape by stepping the section curve along the projection curves and at each stage scaling the section curve until it just fitted between the projection curves.

The only control we placed on the surface at that stage was to decide whether to scale the section curve in one or two directions. Here we will show you how to extend the use of the build command to have several cross-sections of different shapes in a single surface and control the shape of the surface when viewed from another projection direction using secondary projection curves. Let's try it!

Resuming work

If you exited DESKARTES at the end of the previous Lesson, please resume work on the coffee pot model now. Refer to the previous Lessons if you don't remember how.

Building another surface

We'll start building the spout using two projection curves from the x view, and a single section curve. The procedure is very much the same we already used with the handle.

Building the spout from one view:

1. Make a new element [n] and label it spout.

2. Make an x-projection set [p], and show the others [y]. Zoom [z] as required.

3. Input and edit the upper curve of the spout as shown below.
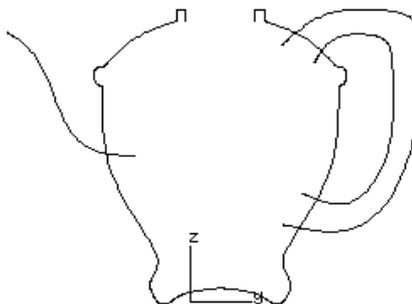
4. Input and edit the lower curve of the spout as shown below. Remember the rules for building surfaces – both projections must contain the same number of points and should be drawn in the same direction!
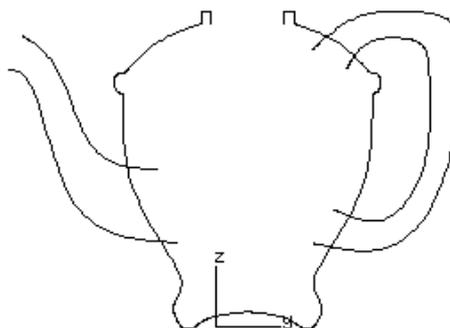
5. Edit [o] the curves. This time, select the projection set before starting to edit. As you see, you will then be able to edit both the projection curves at once!

During editing, remember the projection curves must have an equal numbers of points. If you add or delete a point from one curve, you must do the same to the other curve, too.
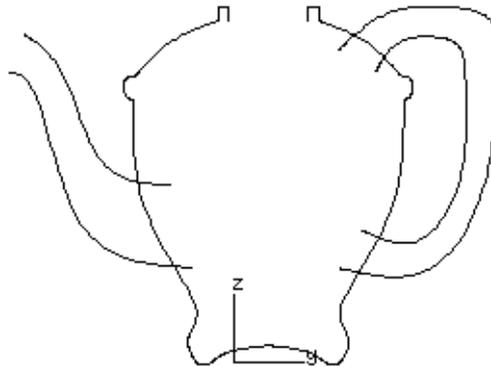
6. Make [c] a cross-section set.

7. Create a circle with 16 points. The radius doesn't matter. Edit the cross-section to a rounded triangular shape as below. Remember to use the mirror function to ensure symmetry.
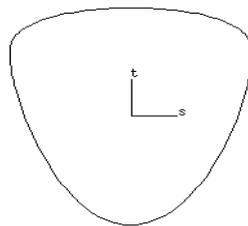
8. Build [b] the surface. Alter the section rotation by 90 degrees using the command BUILD⇒ Set: Build Parameters.
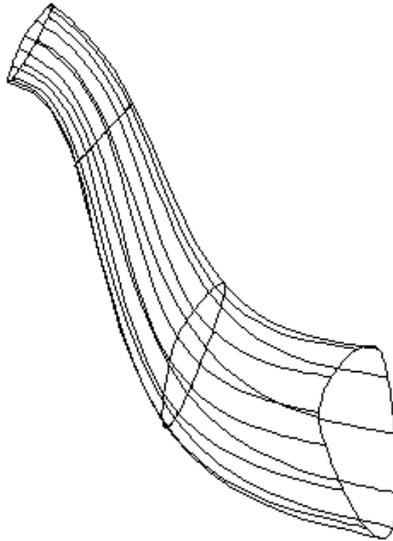
Finally, display the surface with the others (`[t]`, `[y]`).

The techniques briefly described above should be routine to you now. If they aren't you will need to refer back in the Tutorial to refresh your memory.

Varying section curves

You should now have a spout surface, though it may not yet be a very acceptable shape. Patience! It will get better.

We could improve the look of the surface by making the cross-section more interesting and varied. We need a surface that changes cross-section! This is something new.

The first stage in achieving this is to design the second section curve.

To make a second section:

1. Click on the Cross-section curve of the spout in the bottom pane of the object manager.

2. Create a second section by copying `[j]` the original.

3. Edit the section to achieve the shape below. Remember the rules for building surfaces – it is better if all sections contain the same number of points! So, don't add or delete points in the section.
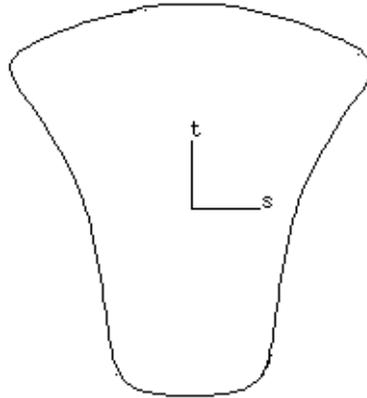
Matching the section curves

Now you have two section curves defined. However, we should check they are suitable for building.

Number of points

Remember that for building, the projection curves must have an equal number of points. Also, it is better if all section curves have an equal number of control points.

Your curves are defined with a different number of points. See for yourself:

To check the number of points:

1. Display the section curves `[y]`.

2. Select the triangular curve [g]. Look at the message lines. You'll notice the curve has sixteen points (16 pts).

3. Select the shaped curve [g]. The message line tells that the curve has sixteen points (16 pts) as well.

Curve directions and start points

The second thing we must keep in mind is that:

- *All section curves must start at the same angle and go in the same direction.*

If this rule is violated the surface will end up twisted.

To check the curve start points and directions:

1. Display the section curves with DISPLAY⇒ All: Fit [y].

2. Select command CURVE⇒ Direction: Show. It shows arrows at the curve start points, indicating the directions of the curve. It doesn't matter where the curves start but they must both start at a similar angle to avoid twisting.

3. If the curve start points do not align use the CURVE⇒ Direction: Revolve command to align them.
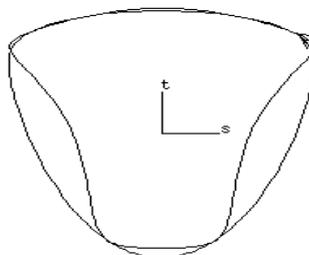
In the case above, everything is correct - both curves start symmetrically at the upper right, and they go in the same direction (anti-clockwise). If required, you could locate a new start point for each curve with command CURVE⇒ Direction: Revolve, and change the directions with command CURVE⇒ Direction: Change.

As you have checked everything you need to, select CURVE⇒ Direction: Show again to switch the arrows off.

Attaching the sections to projections

Before building, you need to tell the system where to apply the sections on the surface.

Section curves are attached to projection curves at *knot points*. Knot points are points that lie on the curves near control points. There are always as many knot points as there are control points.

Displaying section numbers

The projection curve knot points are numbered from one. You may attach a section curve between any pair of knot points on the projection curves. You do this by assigning the knot point number to a section curve as its *section number*.

To display the possible section positions:

- Select BUILD⇒ Show: Section Positions [h].

If the numbers overlap so that you can't see them properly, zoom in and repeat.

You see the knot points appear on the projection curves, numbered and attached with line segments. The lines represent the section curves scaled between the knot points.
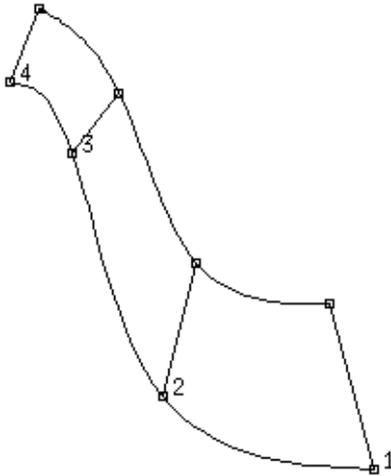
Assigning section numbers

In this case, you want to fix the form of the spout in two places: at either end of the surface. At the free end it will be triangular, and shaped at the body, as described by the two already defined section curves..

To assign the section numbers:

1. Look at the section positions displayed on the screen. Note the numbers of either end of the spout.

2. Select the triangular section curve.

3. Select the command BUILD⇒ Set: Section Parameters [u]. You are asked for a section number. Type the number that defines the free end of the spout. In the above picture, it could be one (1).

   Accept the weight as it is (1.0), and click OK.

4. Select the shaped section curve.

5. Select the command BUILD⇒ Set: Section Parameters [u]. Type the number that defines where this shape should be defined.

How the shape
changes may be
controlled with
the `section`
`weights`.

In the above illustration, eight (8) would be a good choice. The shape will thus smoothly change from the triangular shape to the complex one.

Now, look in your section set. You see items like `curve/Bs/1` in the lowest pane of the object window. The numbers at the end show the curves' section numbers as you just assigned them.

Building the surface

Now that you have the projections and section curves you want, and their numbers assigned, all you need to do is build [b] the surface again.

You can build surfaces with varying cross-sections!
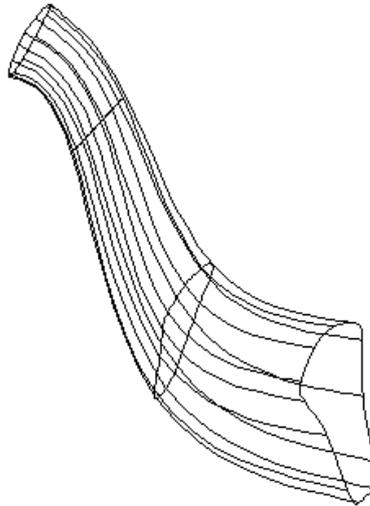
Secondary projections

When you look at the spout from above (the direction of the z axis), you will probably notice that it has a somewhat "lumpy" shape. To change the shape, you will need something called a ***secondary projection.***

Your current projection curves describe the spout as it appears from the direction of the x-axis. A secondary projection is a curve set that describes the surface from

another axis direction. You need to make a secondary projection that describes the shape from above, in other words, a z projection.

To make a secondary projection:

- Select the command BUILD⇒ Create: Secondary Projection. Select z for the projection direction and 2 curves from the dialogue box.

The z projection curves are created. They show how the surface presently looks from the top.

To see the projection together with the base surface, place the eye to Z axis using the settings window buttons (at bottom right), then select and draw [d] the body element.
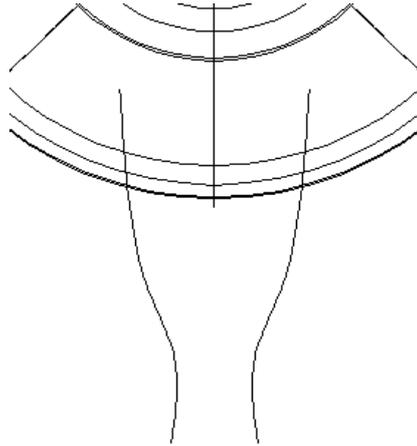
Constraints on secondary projections

The first projection curves you created (the x-projections, called *primary projections*) place some *constraints* on the secondary projection. For example, an object cannot be longer when you look at it from above than when you look at it from the side.

The constraints on secondary projection curves are:

- All projection curves must have the *same number of control points.* Adding a point to one projection curve means that you must add one to all of the others.

- The corresponding knot points of the projection curves must lie at the *same level*. This is because section curves lie on a plane, and you cannot attach the curve to all of the projection curves if their knot points do not lie on the same plane.

- Because of the above constraint, DESKARTES will only allow you to move secondary projection control points in the primary projection direction. For instance, if you have an x projection and make a z projection, you can only move the points of the z projection curves in the direction of the x axis.

Editing a secondary projection

We will smooth out the spout's top shape by editing the secondary projections.

To edit a secondary projection:

1. Select and edit the secondary projection curves [o].

2. Do the following with the left side curve:

   Select the point at the base of the curve with the left mouse button. Make a multiple selection by selecting the top point with the right button. Then use the **p** function to move the points of the curve to a line.
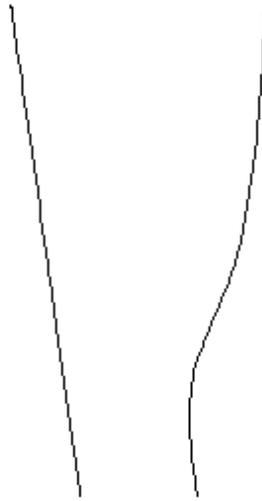
3. Repeat step 2 for the right hand curve.

4. Try also moving the points with the middle mouse button. Notice the system automatically restricts the movements to the allowed projection direction.

5. Exit the edit mode with **w**.

Rebuild the surface (BUILD⇒ Make: Surface) and you now have a nicely shaped spout!

*You can use
secondary
projections.*
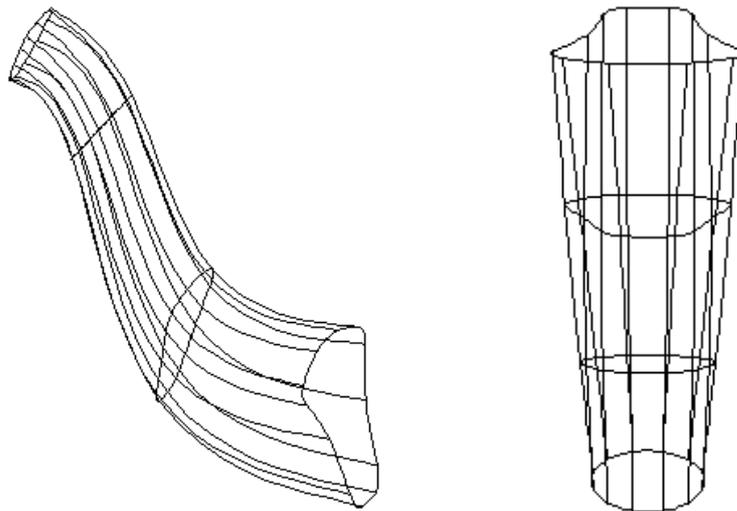
Display [f] and view [v] the surfaces from different directions. You might also
try Rendering again.
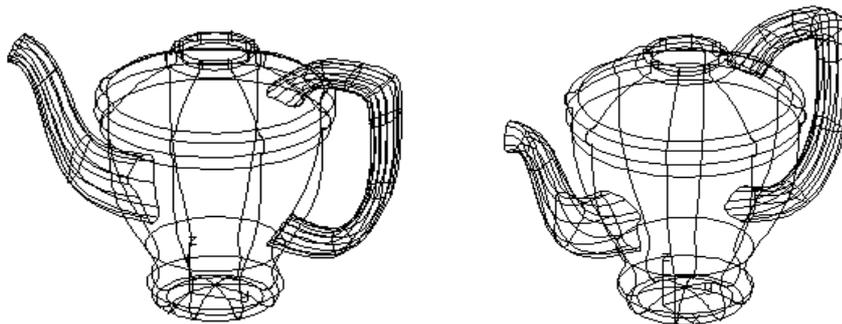
If you feel like you would like to edit the secondary projection further, feel free to do
so. Just remember the rules described above.

?   Problems

If the system *refuses* to build the surface, it normally explains what is wrong with the model. The most typical reason is that you have a different number of points on the projection or the section curves. See the section "Constraints on secondary projections" above, and the "Problems" section at the end of Lesson 6.

If the surface is created, but just *doesn't look right*, there may be something wrong with the directions of the curves. Use the command CURVE⇒ Direction: Show to check the directions, as explained in section " Curve directions and start points" above.

Finally, if you make an illegal secondary projection by moving the control points in wrong directions (DESKARTES tries hard to stop you doing this), the surface will be built but it won't look exactly like the secondary projections.

You can always *update* the secondary projection to make it the same shape as the surface. This is done by giving the command BUILD⇒ Create: Secondary Projection again. Use it whenever you feel unsure of the secondary projection shape.

Ending the Lesson

To end this Lesson, you'll save the work again.

Instead of using the file window let's try a faster way. Writing of files is so frequently done that it is provided with a shortcut in the command menus.

Save your work using a shortcut:

1. Click [w] on the keyboard.

2. Accept the parameter option model (geom_).

3. Accept the model name coffee and click OK.

4. DESKARTES points out that a file named geom_coffee already exists, and asks if you want to overwrite it. Click Yes and OK.

[w] is the shortcut for GET⇒ File: Write. It does exactly the same thing as FILE: WRITE, but it's easier.

Congratulations! You have now finished Lesson 7. You may now exit DESKARTES like you did before, or go directly on to the next Lesson, where you will about connecting surfaces together.

Lesson 8 : Joining the parts

This Lesson teaches you how to cut (intersect) and blend separate surfaces to form a combined model. In the future, when you make your own designs, this is the way to do it: not to build the whole model of one surface, but to combine easier shapes with each other.

Trimming two surfaces

You will now connect the handle to the body surface so that the two objects appear as one. To produce a sharp join, you will *trim* them. Trimming removes unwanted parts of a surface so that they are effectively cut away. In this case, the part of the handle that protrudes through the inside of the body will be removed and a hole will be cut into the body.

To trim the handle to the body:

1. Select the surface in the `handle` element as the target object.

2. Display the handle and the body using DISPLAY⇒ All: Fit [y].
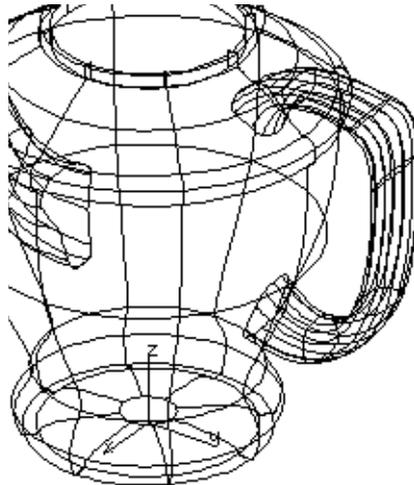
3. Select TRIM⇒ Intersect: Surface.

4. DESKARTES asks for the other surface that is to be trimmed to the target
    (handle) surface. The easy way to do this is by pointing with the cursor at
    the body surface on the screen and clicking. Make sure you position your
    cursor where it is clear that you are pointing to the body.

6. DESKARTES displays the intersection line, that is the line where the handle
    and body surfaces cross over. This should be a continuous loop around the
    handle.

    If the line is broken, it means your handle does not completely intersect the
    body — see the Problems section towards the end of this Lesson for advice.

7. DESKARTES displays the two surfaces again with part of the surfaces
    removed by the trim line.

This surface
means the target
object, the
handle. Other
surface means
the body.
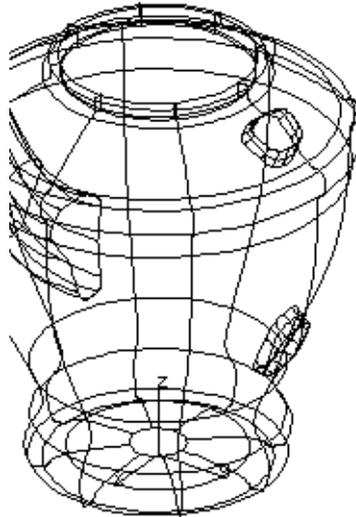
You are asked if which parts of the surfaces you want to keep. If the wrong
part of either surface is displayed you must *invert* it. In the example, this
(the handle) surface had to be inverted.
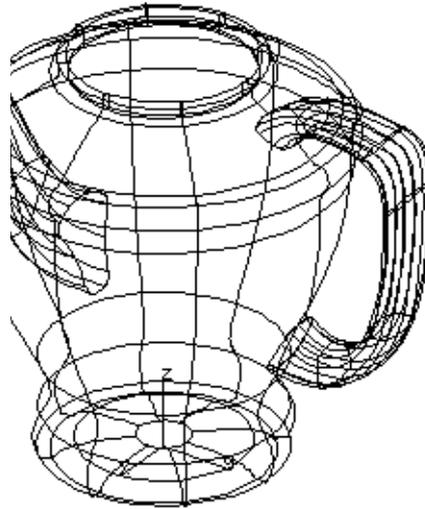
Trimming two surfaces is just one way of connecting two surfaces. Another way of
connecting the surfaces would be to add a smooth blend. Here's how.

Blending two surfaces

To produce a nicely rounded join between the body and the spout, you will **blend**
them. Blending two surfaces is an operation that both:

- produces a separate **blend surface** that joins the surfaces smoothly.

- **trims** the surfaces so that unwanted parts are cut away.

You will connect the spout to the body with a **rolling ball blend**. The shape of the
blend surface is created by rolling a ball of a given **radius** around the two blended
surfaces.

The *direction* of the blend will be determined relative to the surface **normals**.
Normals are shown by arrows on the surfaces, determining what the system
considers to be the "inside" and "outside" of a surface.

To blend the spout to the body:

1. Select the surface in the `spout` element as the target object.

2. Display the spout and the body`[y]`. Zoom `[z]` into the area to be blended.

3. Select `TRIM⇒ Blend: Rolling Ball`.

4. DESKARTES asks for the other surface to be blended. Click at the body surface on the screen.

5. DESKARTES displays the intersection line, that is the line where the handle and body surfaces cross over. This should be a continuous loop around the handle.

    If the line is broken, it means your handle does not completely intersect the body—see the Problems section below.

6. DESKARTES proposes a ball radius. Type `3`.

    DESKARTES also draws little arrows all over the surfaces. These indicate the normal direction.

    To get the blend on the right side of the surface, you must tell the system whether the ball should roll on the `normal` direction of the surface, or on the `opposite` side.
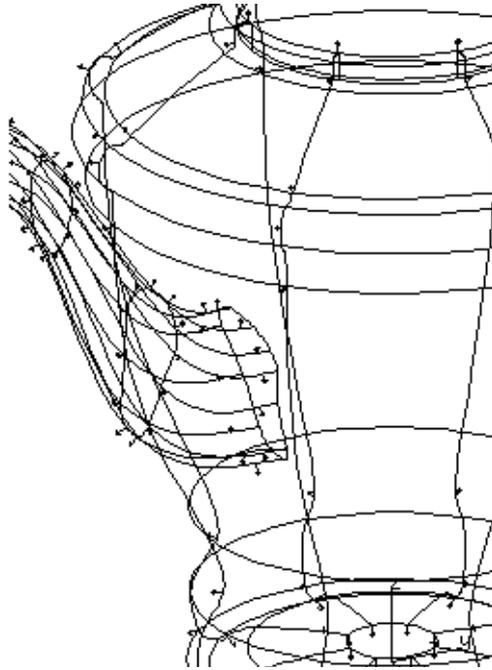
In the above figure the normals point in the "natural" directions, what you would normally consider as the outsides of the surfaces. You would then tell the system to roll the ball on the `normal` directions on both surfaces.

But if, for example, the normals of the spout point in to the model, you would tell the ball to roll on the `opposite` side of `this` (the spout) surface.

9. DESKARTES creates the blend, displays it, and asks if you would like to accept it. The radius we have chosen is very small so reject the blend by answering `NO`.

   Do the same if you accidentally created the blend on the wrong sides of the surfaces.

10. You are asked if you want to continue with a new blend. Answer `YES`.

11. Answer the questions again this time specifying 6 as the radius and accept the blend when it is created.

You have blended two surfaces.
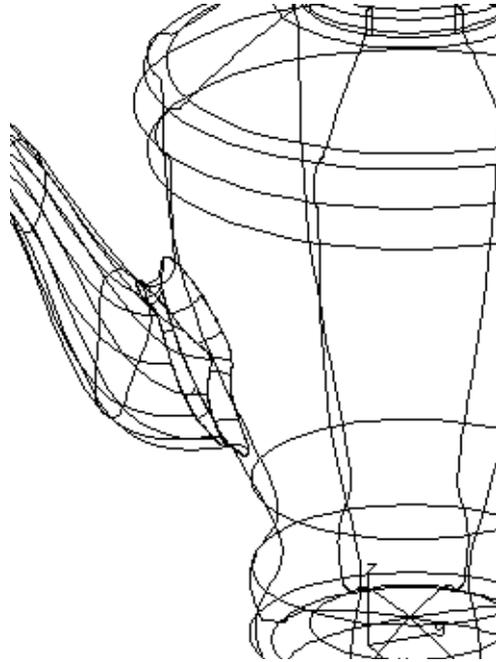
? Problems

If you did not get the cut or the blend computed properly, the most probable reason is that the surface did not completely intersect the body.

You could "push" the handle surface more into the body: UNDO the blend/trim, edit or transform the handle projection curves so they protrude further into the body, build the surface and try blending again.

If you're not happy with the blend for some other reason, for instance, you have accepted a too small radius, again UNDO the blending and try with different parameters.

Reshaping the blend

By default, the rolling ball blend surfaces have a circular arc shape. However, after the blend is computed it is possible to change the blend to have an elliptical or a

slanted shape. For instance, to create a flatter blend surface (a ***chamfer***), you may do the following:

To reshape the blend surface:

1. Select the blend surface `Surf/Bz/blend` in the spout element. Fit it `[f]` and show with the other surfaces `[t]`.

2. Select the command `TRIM`⇒ `Blend: Reshape`.

3. The system asks two *curvature values* as parameters. Answer 0.5 to both, and see the blend change to more slanted shape. Notice the blend is still tangent continuous (smooth) with the other surfaces.
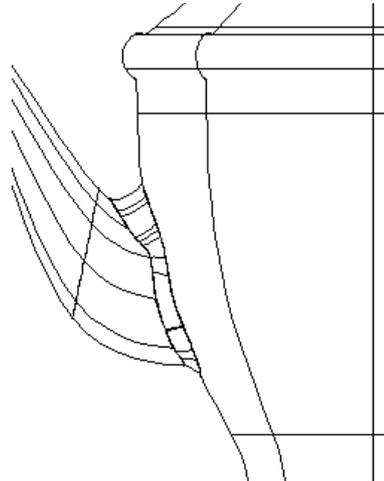
You have a chamfer.

4. Repeat steps 2 - 3 with curvature values 1.5.
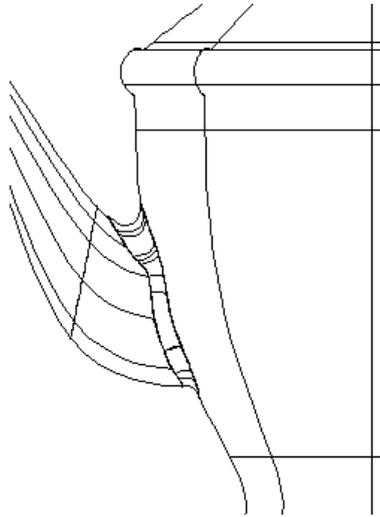
5. If you wish to get the blend back to its original ball shape, repeat steps 2 - 3 with curvature values 1.0.

Recomputing blends

You might still want to modify the blend size, if you consider it too small or large for the model. This means you have to compute the blend again. Let us make a note on that.

You can't use UNDO to get rid of the old blend, as you have already used some other commands after you created the blend. You can of course delete the blend surface, but how about the cuts – they should be removed, as well.

Fortunately, the surfaces are not permanently cut! The cuts (trim curves) are stored separately from the actual surface. This method has the advantage that if the trims are later thrown away the original surface reappears!

See the object window. Within the handle element there is an item labelled "->Trim/body". It contains the cuts (trim curves) of the spout surface, as we combined it with the body. The same applies to the handle as well.

How to interact with trim curves is more closely explained later, in Lesson 16. But if you now wish to recompute the blend, you may apply the simplest (and the crudest) method: delete [k] the "Trim" objects of both the body and the handle before blending again.

PreViewing

However you achieved it, you should now have the body, spout and handle surface joined nicely together. Shade the model with PREVIEW⇒ GL: Default to view the shapes. Remember how this is done? If not, please refer back to Lesson 4 for instructions.

Ending the Lesson

When you are happy with the coffee pot, save it in the model file named coffee. Then continue with the next lesson…

... or you might like to learn more about visualisation right now. This Tutorial is designed to meet your needs! Go ahead and jump directly to Visualisation if you wish, but in that case make sure to return here later on …

... but if you now have a problem in deciding where to go, we recommend you just turn the page.

Lesson 9 : Putting the Lid on it

In this Lesson, you will add the lid to your coffee pot. The lid will be made by building like the handle and the spout. Even though this is a circular shape, we need to build it because the cross-section varies. This would not be possible by simply using the SURFACE⇒ Rotate: command. We have built two surfaces already (the handle and the spout). Although nothing new will be introduced with the lid the Build command is so important it is worth reviewing again.

We'll also take the opportunity to introduce some new things, which we haven't discussed yet. As a vehicle for this we will design a repeated, raised pattern on the surface of the lid.

So far all curves we have been drawn have been so called B-Splines. The outline of the pattern will be designed using a new type of curve, the Bézier curve. This curve will then be used to create a new type of surface called an extrusion. The extruded surface will be replicated, transformed and rotated in 3D to define eight raised patterns in total. This is done using the automatic command sequence feature of DESKARTES. Finally, the details are connected to the lid with a multiple intersection command.
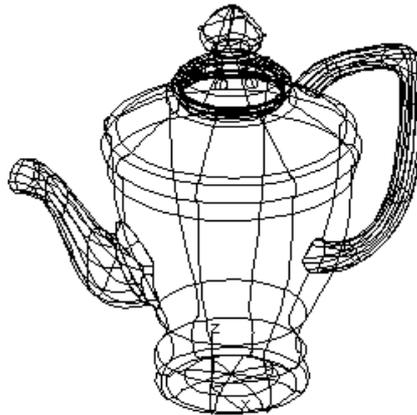
Building Surfaces - A Review

The surface building command creates a surface that follows the shape of the projection curves from the projection direction. For a surface such as a lid you need to create two curves which in this case will be identical to define each side of the lid.
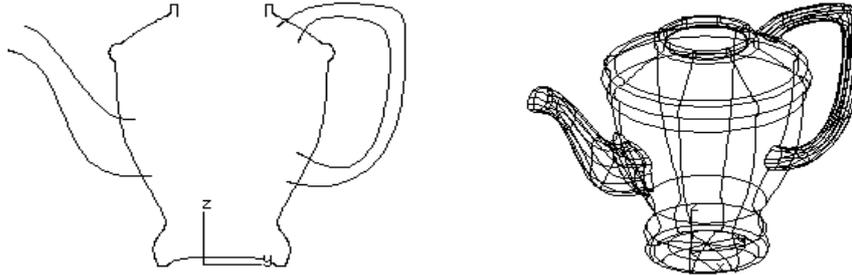
Creating the projection curves

Make projection curves for the lid:

1. Make a new element and label it `lid` (use `OBJECT⇒ New` - remember?).

2. Make an x-projection set (`OBJECT⇒ New`).

3. Display the existing projection curves. Remember this is achieved by the `DISPLAY⇒ All: Fit [y]` command.

4. Zoom `[z]`/*right* button around the top of the body.

5. Input and edit the curve for the lid as shown below.
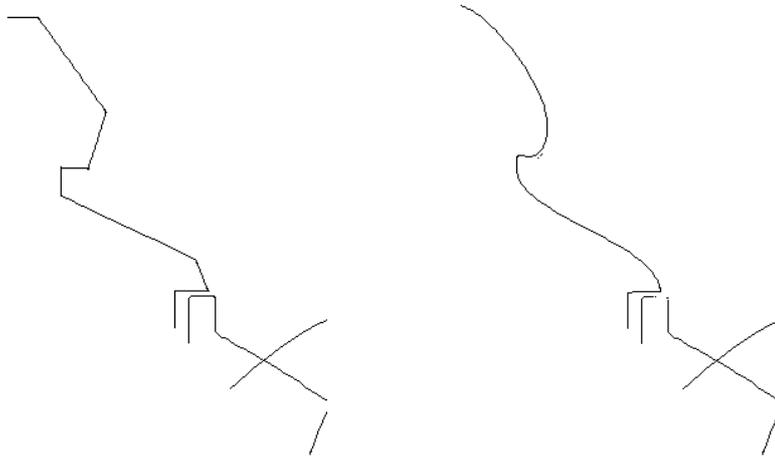
6. Issue the command OBJECT⇒ Copy [j] to copy the original curve.

7. Set the FIXED POINT to the centre end of the curve. Mirror this copied curve horizontally about the fixed point.

8. Scale and move the PROJECTION/X curve set until the lid fits on the body.
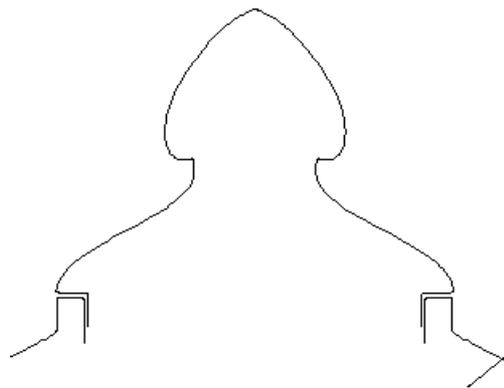
Create a section set:

- Perform OBJECT⇒ New [n] and select cross-section from the dialogue box.

Or

- Use the faster alternative, GET⇒ Object: Cross Section [c]!

To create a circle:

1. Select the command CURVE⇒ Design: Circle.

2. Type 8 for the number of points to use. Click OK.

The circle appears around the origin of the co-ordinate system.

To create a rounded square

1. Select the command CURVE⇒ Design: Circle.

2. Type 4 for the number of points to use. Click OK.

3. Edit the curve and copy all control points to double points using the **[S]** function.
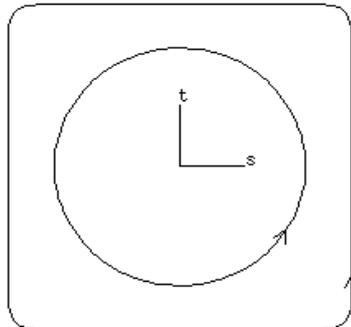
Building the lid

Before building the lid one thing remains, to assign the cross-sections to their position on the lid. Use BUILD⇒ Display: Sections Positions [h] and note the numbers on your curve which are nearest to R and S in the diagram below. Use BUILD⇒ Set: Sections Parameters [u] to assign the circular section to R and the square to S in the diagram below - remember your numbers may be different.

Now you have finished the projection curves and the section curve, you will want to build the surface. Select the command BUILD⇒ Create: Surface [b] and the lid appears.
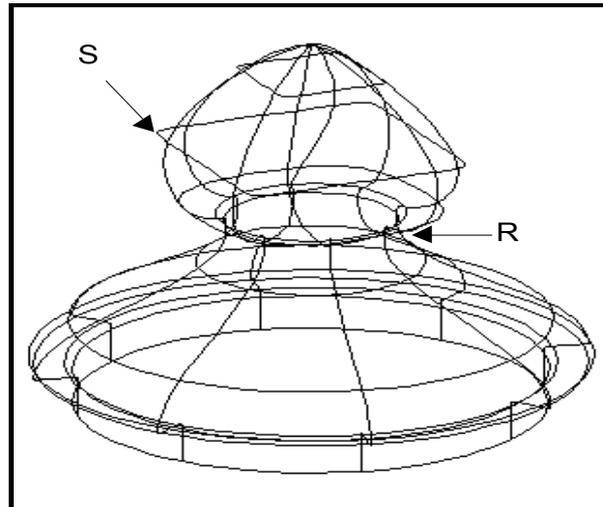
Simple Embossing

Embossing is the technique whereby a pattern is added to the surface by raising the surface to form a relief. The patterns thus created in ceramics using this technique vary from Grecian ladies carrying urns (very complex) to simple geometric patterns. We will leave the Grecian ladies for now, instead showing the principles of the technique by using a simple geometric repeated around the lid.

Creating the pattern

If you didn't continue directly from the previous Lesson, read in the `coffee` model before you start.

Make `[n]` a new element called `pattern`.

Creating a primitive surface:

1.   The embossing will be formed by raising a ring of spheres in the lid.

2.   Spheres are one of the standard shapes built in to DESKARTES as primitives. Primitive surfaces do not need any curves to define them.

3.   Use the command `Surface`⇒ `Design: Primitive` to make a primitive surface. Select the option for SPHERE and in the dialogue box change the radius of the sphere to say 4.
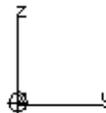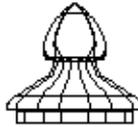
Note that a new surface is created directly, without any defining curves. The sphere is created by default at the origin of the system.

Transforming surfaces

The primitive surface is located at the origin - nowhere near the lid! We need to move it to the correct position

If you view a surface from an axis view, the transformation commands work exactly as in the case of 2D curves. So here's what to do:

Moving the surface in one direction:

1. Set the eye point to X view.

2. Give the moving transformation command with the primitive surface to be moved selected [1].

3. Press the *left* mouse button and move the mouse. The surface is moved freely in the y and z-axes. Move the surface until it is positioned in the correct position relative to the lid as shown below. You may have to move it near to where you want it and then zoom in before moving precisely.

If you make a mistake here, use UNDO, or extrude the surface again.
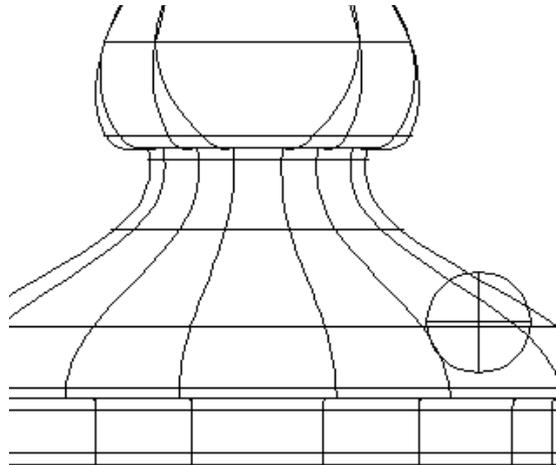
4. When you are happy with the transformations, set the viewing direction back to 3D.
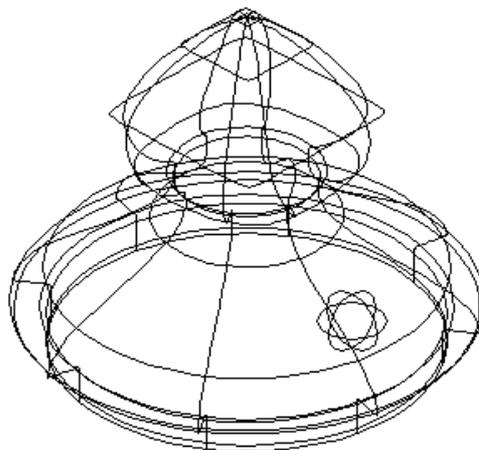
Teaching a command sequence

Now you should have the pattern (sphere) positioned correctly to raise a surface on the lid surface. However, we would like *eight* patterns. Easy you might think! I can copy the surface I have just created and then rotate it round the centre of the lid about the Z-axis by 45 degrees, repeating this operation seven times. Yes, that's correct, but DESKARTES can make it even easier for you!

Whenever you need to repeat the same operation, many times you may teach DESKARTES a *command sequence* (or, a *lesson*) and then replay it a number of times.

Before you start teaching DESKARTES the lesson, it's a good idea to take a few moments to review the series of commands that you need to complete the intended operation. You wouldn't want to teach DESKARTES to make mistakes would you!

In this case we just need to make a copy of the selected element - the sphere, and rotate it numerically by 45 degrees about the centre of the lid. First, we need to set the fix point for the rotation:

Setting the 3D fix point:

1. Select the `lid` surface.

2. Give TRANSFORM⇒ Fix Point: Set [0]. Click the *middle* mouse button. This sets the fix point to the centre of the lid surface, indicated by a 3D cross there.

3. Select the pattern primitive surface. Copy the previously shown fix point to the pattern surface with TRANSFORM⇒ Fix Point: Copy [9].

You are now ready to teach the lesson

Defining a command sequence:

1. Select the pattern primitive surface.

2. Click TEACH in the settings window. A dialogue box appears asking you for a name for the command sequence. Type in the name "rot45". Click on OK.

3. Select the command OBJECT⇒ Copy [j].

4. Select the command TRANSFORM⇒ Rotate [3].

5. Press *any key on the keyboard* and type 45 into the dialogue box that appears. Select rotation about z-axis. Then click OK.

6. That's all there is to it! Click TEACH again to end the lesson.

To replay the command sequence, simply click EXEC in the settings window and type six (6) for the number of repetitions (two of the eight tools are already created). Click on OK, sit back, and watch DESKARTES do all of the work.

At the end your model should look like the picture below.
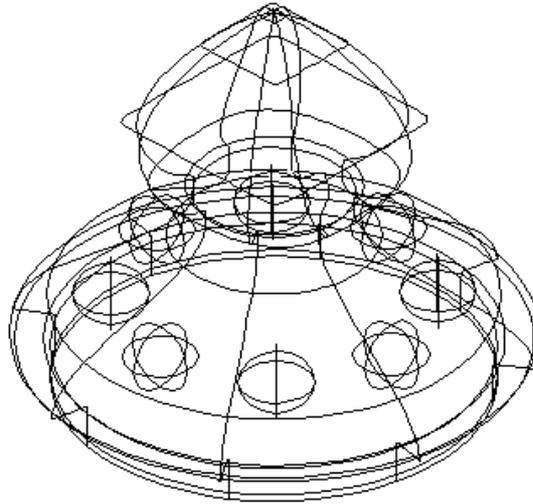
Adding the Patterns

So, we now have eight patterns in the correct position. All that remains is to join the patterns and the lid. This is an example on how to intersect more than two, *i.e.*, multiple surfaces at a time.

To make a multiple intersection:

1. Erase the screen [e].

2. Select the pattern **element** (not surface!) and fit [f] it on the screen.

3. Select the lid **surface** (not element!) and draw [d] it.

4. Select TRIM⇒ Intersect: Multiple. DᴇꜱᴋAʀᴛᴇꜱ displays the normals on the lid surface and asks which side of the pattern surfaces to keep. You need to keep the part above the lid. Select the correct option for example the opposite side in the diagram below.
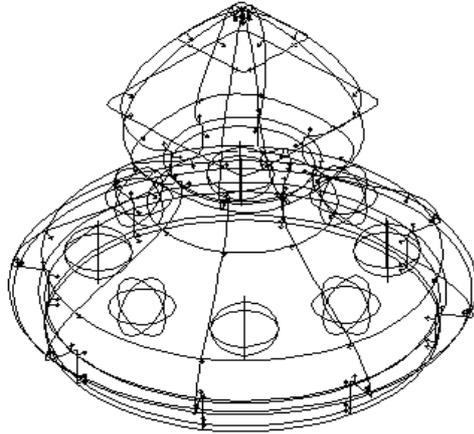
5. DESKARTES intersects all of the displayed surfaces with the pattern target surface.

    When the cuts are done, a dialogue box appears. If the wrong parts of the lid were cut away, *i.e.*, only the holes remain, tell the system to invert the lid surface. Otherwise, just click OK.

Hope you had the right surfaces displayed and selected, if not pick UNDO.

You have cut multiple surfaces!
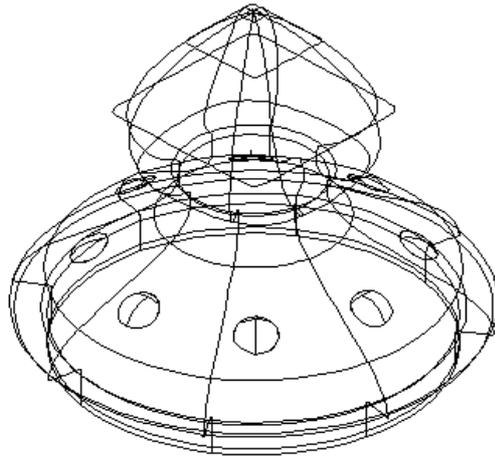
Ending the Lesson

When you are happy with the coffee pot, save `[w]` it in the model file named `coffee`. You are then ready to continue with the next Lesson.

Lesson 10 : Making Use of It!

In this Lesson, you will prepare your model for communicating the design on to other members of your organisation or to customers.

Traditionally the information would be passed on by means of a *2D drawing*, probably showing one or more orthographic projections with key dimensions shown. DESKARTES supports not only this method, but also more advanced methods of exchanging *3D geometric data* by electronic means.

The information, which is currently stored in the DESKARTES's own personal format, can be written into many international *data exchange formats* supported by DESKARTES. Having converted the model into such common format it can be used by different computer manufacturing systems to create a physical model of your design.

Creating a line drawing

The model of the coffee pot is now complete, at least for the purposes of this exercise. So now, it's time to produce a dimensioned line drawing of the model. We will look at two ways of achieving this. First, we need to load the coffee pot model again.

Start DESKARTES the same way as before. Select your model file (geom_coffee) and give the FILE: READ command. Hide the file window and begin work.

Making a drawing of the projections

You should by now be very familiar with the much used command DISPLAY⇒ Fit All [y]. We have used it many times already to fit all of the objects of a *similar type* on the screen at once. For example, if you click on any surface and click on [y] you will see your entire model on the screen

You may consider this command to be useful in producing a drawing since if you issue the command with an x projection is selected you will see all of the x projections on the screen. Almost a drawing in itself! There is another command in

DESKARTES that has a similar, but a more powerful effect. It is the
OBJECT⇒ Collect command.

To collect objects together:

1. Click on the type of object you want to collect, in this case an x projection.

2. Issue the OBJECT⇒ Collect command.

Notice the top sub-window in the object window. A new element has appeared. It is called -ALL. This contains a *copy of the objects* of the same type you selected. Since we selected x projections these can form the start of drawing, though some work is still needed.
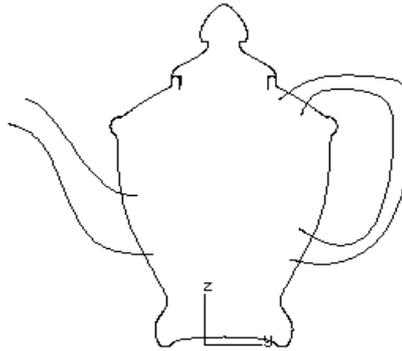
The next step is to tidy up the drawing by removing the unwanted parts of the curves, for instance the handle fitting inside the body. Remember it doesn't matter what we do to these curves, since they are *copies* of the original curves. The original curves, which define the surfaces, are still stored in their original elements.

To cut curves with each other:

1. Click on the x projection set in the ALL element.

2. Issue the CURVE⇒ Combine: Cut All command.

This command *cuts* every curve in the set into separate pieces, ending where the curves cross each other. Notice how they are displayed with different colours.

So now the portions of the handle curves which protrude inside the body are isolated. To remove these portions it is a simple task of *deleting* them from the model.

To remove unwanted portions of curves:

1. Issue the command GET⇒ Object: Pick [g].

2. Point on the screen with the cursor on a curve segment which you wish to delete.

3. DESKARTES finds the picked object and selects it. Issue the command OBJECT⇒ Delete [k] to remove the object.

4. Repeat steps 3 to 5 to delete all of the curves not required for your drawing.
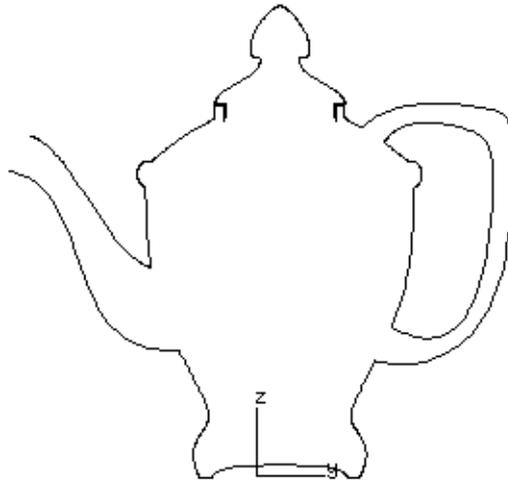
To complete the drawing operation, *join* all the curves to form as few separate curves as possible. This is effectively the opposite of the cut command introduced earlier.

1. Select the curve set.

2. Issue the command CURVE⇒ Combine: Join All.

Finally, you could now go and edit the curves to *add the blend shapes*. Display the surfaces from the X direction, select the body/handle curve in the ALL element, and edit it to follow the blend surface shape, as below.

The curves are changed from B-Splines to Bézier when cut.
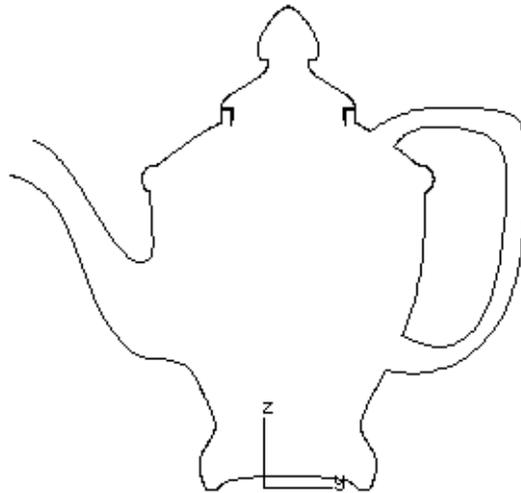
Making a drawing by slicing

An alternative, and more automated method to produce a drawing, is to compute the *plane intersection curves* through an object. The TRIM⇒ Intersect Slice command is available for this.

The command is really just a special case of the TRIM⇒ Intersect: Multiple, but it is not intended to trim back parts of surfaces. Instead, it generates the 3D intersection curves of the cut. This, among other applications, allows you to use them as the basis of a drawing. An example will explain this.

To generate a slice:

1. Display [y] all the surfaces you want to slice. Change the eye point to Y direction.

2. Generate a plane in the middle through the object, as follows.

   Set the grid on. Make a new element called slice, and a y projection set in it. Input a curve which extends from above the top to below the bottom of the coffee pot.
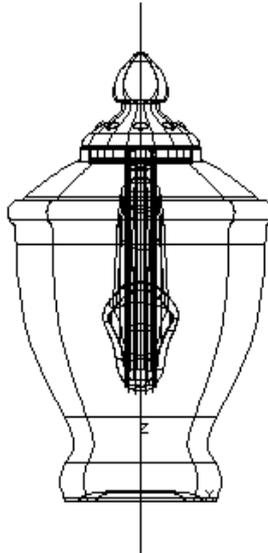
3. Extrude the curve to make a plane: give SURFACE⇒ Design: Extrude, accepting its default parameters.

4. Change back to 3D view and fit [y] the surfaces on display.
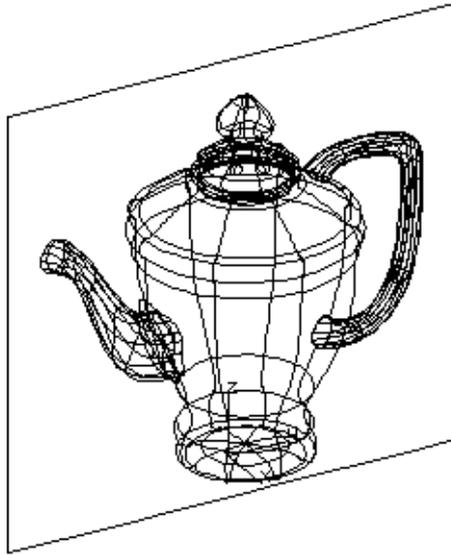
5. Issue the command TRIM⇒ Intersect: 3D Slice, and accept the joining accuracy parameter. The command intersects all the surfaces on display with the target object (the plane).

    Select the sliced curves, called Curves/3D in the object window. Erase [e] and display [d] to see the slice.
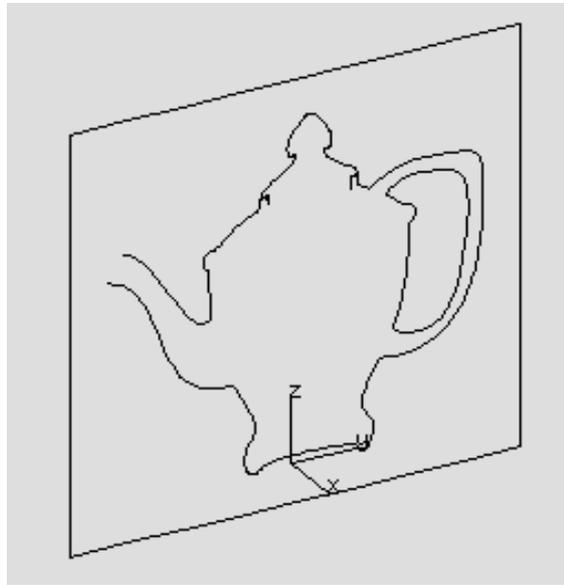
6. Change the resulting 3D curves into a 2D Drawing using the command CURVE⇒ Change: Dimension. Set x to be the direction to project the curves into plane.

These two methods of creating a drawing are presented as alternatives. You will no doubt favour one of the other, depending on the application. Keep in mind the two methods as they both have a role to play.

Dimensioning a curve

You should now have a complete line drawing of the coffee pot. All that remains is to add some *dimension lines* to indicate the intended properties of your model.

This is achieved in DESKARTES by using yet another editing mode, called *curve dimension mode*.
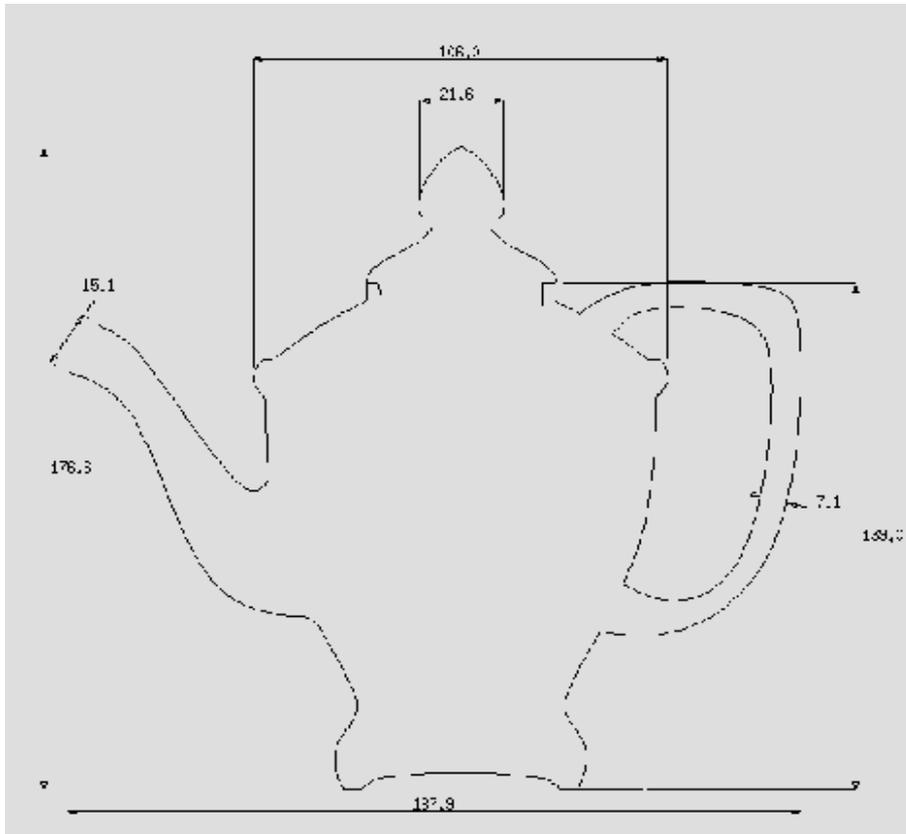
To start curve dimension mode:

1. Select the curve set you want to dimension, *e.g.*, the `Drawing` object in the `slice` element.

2. Issue the command `DIMENSION`⇒ `Curve: Dimension`.

You will see a new set of icons that describe the functions available in curve dimension mode. Experiment with them, and try to create a drawing like the one below. Only the interaction guidelines are provided in the following, for further details, consult the DESKARTES Reference Manual.

Cancelling an operation

Sometimes you might want to undo something you did while dimensioning. Don't do this now, as you haven't done anything yet, but note that while adding dimensions as explained below, you can at any time undo the last change made:

To undo the previous operation:

- Click on the icon that looks like a clock running backwards, or click **u**.

Bounding box dimensions

This icon allows you to quickly add the dimensions describing the overall size (*extents*) of the curves in both the horizontal and vertical directions.

To add bounding box dimensions:

1. Click at the bounding box icon **b**.

2. A line appears stretching vertically across the full extent of the curves.

3. Click and hold the mouse button near the line. Move the mouse and the line follows allowing you to position your dimension line in the most suitable place.

4. Release the button to place the dimension line.

5. You may now place the dimension value at will. Press and hold the *left* mouse button, move the number, and release the button when ready.

6. A line appears stretching horizontally across the full extent of the curves. Repeat steps 3-4 to place the line. Instead of repeating 5, however, click at

the *right* mouse button after the line is in place: the value drops to its default location.

Steps 5 and 6 above present the general interaction rule with dimensioning:

- To *place* the dimension value, click at the *left* mouse button.

- To accept the *default* value location, click at *right*.

Distance dimensions

These icons allow you to quickly measure **distances** between any two points on a curve. There are three similar tools which add angular, horizontal or vertical distance dimensions between two points. Try the first one now.

To add a distance dimension:

1. Click at a distance icon **d**.

2. You now need to indicate two points that DESKARTES will add dimensions between. For the first point, press *and hold* the left mouse button at one side of the curve that you want to dimension.

   Still holding the mouse button down, move the mouse, and a line appears. Move the line so that it *intersects* the curve at the point you want to dimension.

3. Repeat step 2 for the other end of the dimension line.

4. Place the dimension line as with the **b** function above.

There is a special effect to the above interaction:

- To pick an *end point* of a curve, just *start* your intersecting line near it, but *don't intersect anything*.

Try this technique, too.

Thickness dimension

This function works effectively like **d**, but draws the dimension lines outside to the curves:

To add a thickness dimension:

1. Click at a distance icon **t**.

2. Press *and hold* the left mouse button at one side of the curve which you want to dimension.

   Move the mouse, and a line appears. Move the line so that it intersects the curve *through both the two points* you want to dimension.

3. Place the dimension line as above.

Exiting curve dimension mode

The radius function **r** won't work for this model, as it's completely free-form.

You have learned to dimension a curve.

So that's for starters. Before going on to the next section, add some dimensions to your curve until you feel familiar with the interaction.

To store the curve dimensions:

- Press **w** on your keyboard, or click at the Smile icon.

This way the changes you made will be saved. The dimension lines and values appear as another Drawing in the object window. It is made separate from the actual curves so that it could be *plotted* separately, using different line width, pen colour, and so.

If you would like to abandon the dimensioning lines you've made, click at the Sorry icon, or press **q** on the keyboard. This exits from curve dimension mode

without saving the dimensions added, though they remain on the display for checking.

Transferring information electronically

In your brief experience of working with DESKARTES you have seen it to be an efficient tool for generating *computer based design ideas.* As such it has the potential to allow a designer to experiment with many more design ideas and/or provide a much quicker turn around of new design proposals. This translates into *shorter lead times* of new products allowing a company to maximise market leadership.

The potential is actually much greater if a product is going to be brought to market using *computer based manufacturing techniques*. For example, if your product requires moulds or press patterns these complex shapes can be produced using Computer Numerically Controlled (CNC) machines. To control these machines for complex shapes a computer based model is required.

But wait a minute! We have just created a computer based three-dimensional model in DESKARTES! Do you see the potential? Rather than giving your manufacturer a drawing, you can give the manufacturer your DESKARTES model and they can use that, right away!

Not quite! There are thousands of computer aided design software's available and they all use their own *format* for storing the information that defines the model. They all speak different "languages". Just like spoken language, a *translator* is needed.

In fact, there are several "translators" available, but only a few of them are important. The three significant ones are called *IGES*, *VDA-FS* and *DXF*.

 DESKARTES supports all of the major translators!

So to pass information from DESKARTES to another system, all that is required is to:

1. Find out which translators your manufacturer's CAD system understands. It is almost certain that it knows one of the above mentioned formats.

2. Agree which format you will use to transfer data.

3. Convert your DESKARTES model to the agreed format (see below).

4. Pass the information to your manufacturer via means of floppy, tape, CD disk or electronic mail.

5. Upon receipt of the information, your manufacturer can convert the information into the native language of their CAD system.

Step 3 above is equal to all formats. It's just as simple as writing a DESKARTES model file!

To write a data transfer file:

1 Select the target object you wish to transfer, *e.g.*, a collected ALL element of the surfaces.

2. Call up the file window in the normal manner.

3. Select the command FILE: WRITE from the middle field pop-up menu, just as if your were going to save a model file.

3. Choose the data transfer option. Click OK.

4. Choose the desired data transfer format. Click OK.

5. Enter a name for the file in the dialogue box. Click OK.

You have learned to transfer data.

On completion you will see a new name appear in the middle field of the file window. It will be the name you typed, with the format identifier ".igs", ".vda" or ".dxf" appended. This is the data transfer file you should now pass on.

PART III: VISUALISATION

The Visualisation Part consists of five Lessons, all of which work on the models you have already produced with the Tutorial. They are called `geom_bottle` and `geom_coffee`.

The five Lessons introduce different levels of visualisation. You'll also learn how to perform various file management operations on the way.

In the first Lesson you will compose the layout for the objects to be visualised in the remaining Lessons. You will learn more about 3D transformations.

The second Lesson will show you how to apply different properties to a model to determine how it will appear. These consist of the object's material, including colours, and texture images mapped on the surfaces. You'll use PreView for the visualisation, with some advanced techniques to control the picture contents.

The third Lesson introduces the concept of scene elements. They are controlled with the DESKARTES scene editor. It will allow you to position the camera and light sources, define their view angles, colours, intensities, and see the changes shaded in real time.

In the fourth Lesson, the picture thus composed will be rendered to the highest quality by ray-tracing. You'll also learn many ways how to interact and add scene elements with ExTrace.

The final Lesson teaches you to use DESKARTES's painting program to create your own graphic designs. You'll design a simple texture, which finally will be mapped onto the complete coffee pot model.

Lesson 11 : Composing the Scene

In this Lesson, you will learn how to combine models from different files, and how to transform the models in the 3D space. In the process, you will form a scene that will be visualised in the next Lessons.

Combining models from two files

You will now **combine** two models from different files, to form a complete scene. The models you will use are the ones you have already created, the bottle and the coffee pot. To combine these, it is easiest to make a "scene model" by collecting the surfaces from the two models into your active model space.

To collect the surfaces of the coffee pot:

1. Start DeskArtes as usual.

2. From the file window, select the `geom_coffee` file and perform `FILE: READ`.

3. Select any surface, and issue the command `OBJECT⇒ Collect`. This copies all your active surfaces into a new element called "`ALL`".

The ALL element is passive, by default, as it contains just copies of the actual surfaces.

4. Select each of the other elements in turn (*i.e.*, `body`, `spout`, `handle`, `lid`) and delete them using the command `OBJECT⇒ Delete [k]`.

5. Rename the `ALL` element: select it, perform `OBJECT⇒ Rename`, and type `pot`.

6. Make the `pot` element active with `OBJECT⇒ Active/Passive [a]`.

You now have an element called `pot` which contains only the surfaces, no curves. Next, read in the bottle:

1. From the file window, select the `geom_bottle` file and perform `FILE: READ`.

2. The system asks, whether the old model should be replaced or not. Answer `NO` since we want to combine the two models. Then hide the file window by clicking on `OK`.

You have combined models to make a display file.

3. Remove the projection and section curve sets from the `bottle` and `cap` elements (`OBJECT`⇒ `Delete [k]`).

You should end up with three surface elements called `pot`, `bottle` and `cap`. Additionally, you have two extra elements called `SCENE` and `MAT`. These contain the scene descriptions of the ExTrace picture you created of the bottle in Lesson 4. Leave the elements there for further use.

Transforming the models

When you now display the elements with `DISPLAY`⇒ `All: Fit [y]`, your coffee pot and the bottle appear in the graphics window. However, you have a minor problem: the bottle and cap occupy much the same space as the coffee pot.

You want to move the coffee pot out of the way. Here you'll learn how to *transform surfaces in a 3D view*, and using *multiple viewports*.

Graphical moving

Move the coffee pot away from the bottle with the mouse.

To move the coffee pot in 3D:

1. View the model from a 3D view. Zoom out to have more space for moving, using [z] and *right* mouse button.

2. Select the pot element in the top pane of the object window.

3. Select TRANSFORM⇒ Move [1].

Look at the message lines for instructions.

4. A box appears around the coffee pot to show the coffee pot location in real time. Press and hold the *left* mouse button. Move the mouse, and the coffee pot (box around it) moves in the x direction.

   Release the mouse button when you are finished moving.

5. Repeat steps 3 - 4, and move the coffee pot in the y direction: use the *middle* mouse button to do this.

You may recall the transformations behave differently if the eye point is set to one of the co-ordinate axes:

To move the coffee pot in an axis view:

1. View the model from the Z axis view (click on Z in the settings window). Fit the objects on screen with [y].

2. Move the coffee pot using the mouse. It now moves just like 2D objects.

Four views

So far we have used the just one view in the whole of the graphics window to display the models. But there's an alternative to this.

If you click at the Area: four button in the settings window (do it now!), DESKARTES shows the objects in the three orthographic views *and* the 3D view, all at once. You may fit the surfaces in all display quarters with [y], and zoom in each quarter separately using [z].

This *four views mode* is particularly useful for performing transformation on 3D objects, as it helps to see where the objects really are located. During transformations, all the four views are updated when the object is moved.

Mouse buttons in different views

The transformations are slightly different if performed in an orthographic view, or in the 3D view. With four views, the behaviour depends on *which view* the mouse button is clicked at. Let us summarise the basic rules:

- If the cursor is in a *3D view* for a transformation command, then movement with the mouse buttons is locked to one of the three axes.

  Left mouse button moves in X, *middle* moves in Y and *right* moves in Z.

  Rotation behaves similarly, rotating around X, Y or Z axis depending on which mouse button is pressed.

  Scaling is done uniformly in all directions, regardless of the mouse buttons.

- In an **orthographic view**, the *left* hand mouse button allows free movement.

  The *middle* button locks the transformation to either vertical or horizontal depending on the first movement of the mouse (like 2D transformations).

  The *right* mouse button works like the left, but it restricts movement to grid or other set increment.

- All transformations, regardless of the view, can be performed *numerically* if you click on any *key* on the keyboard instead of a mouse button.

Let's try these alternatives. You should have the `AREA: four` button pushed down and the coffee pot model selected when performing the following exercises.

Scaling and rotation

The coffee pot is probably the wrong size compared to the bottle. You might want to scale it.

As with 2D transformations, it is best to set the fix point to the middle of the object before the transformations.

To scale the coffee pot:

1. Select the command TRANSFORM⇒ Fix Point [0].

   Press the *middle* mouse button in the 3D viewport. This sets the fix point to the middle of the coffee pot.

2. Select the command TRANSFORM⇒ Scale [2].

   Press any mouse button in the 3D viewport and scale the coffee pot to a suitable size.

Continue with the transformations until you have the objects in the right place and the right size. Try also rotating [3] around the z axis both in the 3D view (use *right* mouse button), and the Z view (with any mouse button). You should end up with something like this:

You can transform 3D models.

Ending the Lesson

Exit the four displays mode by clicking Settings⇒ AREA: whole.

Save [w] your work into a model file name named collection, so you can continue to use it for visualising in the next Lessons.

Lesson 12 : Materials and Textures

The models you have so far created have been defined by their shape. But shape is not the only thing that determines how an object looks. Both the *material* an object is made from and its *texturing* affect the final appearance. The material defines the surface structure, or its "shininess", while a texture is a pattern, a painting, a label, or a relief which appears "on top" of the material.

The way the object is lit is of course important, too, but let's not rush ahead of things! Before you can play with the lighting conditions, you should define the materials for your objects.

Have the `collection` model loaded in DESKARTES to perform the following exercises.

The material palette

Materials are defined and edited through a single menu command, `SCENE`$\Rightarrow$ `Material Palette`. Give the command now.
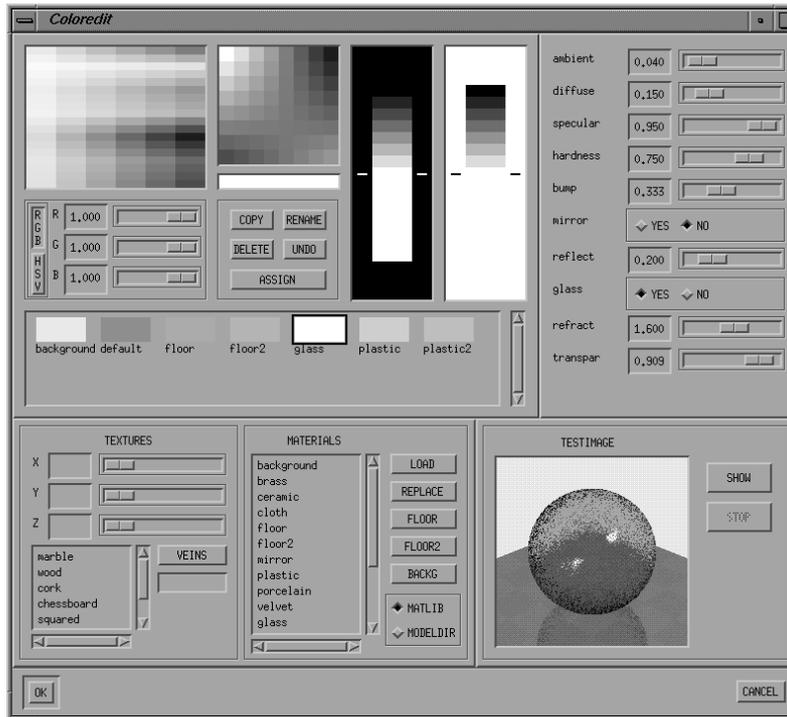
A large window, the **material palette**, appears. It contains all the functions to define materials and may at first appear quite complicated – it isn't! To prove it let's work through a **material editing session**. The coffee pot will be made of a porcelain material and will be a light pastel green in colour.

Default material

In fact your model always has a material. If nothing else has been defined, the **default material** is used.

You have already seen the default material in the various PreView pictures you've created. It is shown in the material palette's list of **currently defined materials**, at middle left, in a box labelled "default". The default material is a greyish nondescript material. Very boring! So let's define something a little more exiting.

Library materials

First because we have already decided the material will be porcelain let's look in the *material library* to see if the there is a predefined material we could use. The material library is accessed through the middle bottom window headed MATERIALS.

To load a material from the library:

1. Scroll through the list of materials until you find a suitable name. Try the one called "porcelain".

2. Click on the material name to highlight it.

3. Press the button LOAD.

Notice that when a material is loaded all of the controls alter to reflect the properties of that material. Now let's see what the "porcelain" material looks like.

Test object

In the bottom right of the material editor you will see the *test object window*. Press the button labelled SHOW and watch what happens. A picture of a test ball is rendered. The ball has the properties of the current material - "porcelain". Use the test object to show your material changes whenever required.

Do you like the porcelain material? If you don't it doesn't matter, your not stuck with it! Let's change it's colour first.

Colours

Colour on the computer screen is produced by combining three different colours— red, green, and blue—in varying combinations. For a DESKARTES material you can define your own colours in the same way, by numerically specifying the red, green and blue components. But DESKARTES also allows you to *interactively select and mix* colours on the screen in much the same way as an artist mixes paint.

To select a colour:

1. Select a colour with the *left* mouse button from the basic colour field, at top left.

2. Zoom the colour by clicking the *middle* mouse button. This displays a more accurate colour chart around the selected colour.

3. You may select any of the zoomed colours with the left mouse button.

3. Click the middle mouse button again to return to the basic colour chart.

The *colour mixing field*, at centre top, allows you to create your own colours.

To mix a colour:

1. Click on any colour within the colour palette window to select it.

2. Click the *right* mouse button on a *corner* of the colour mixing field. The selected colour drops there, and the shades inside the colour mixing field change correspondingly.

3. Repeat steps 1 and 2 for the other three corners.

4. Select and zoom the colours within the colour mixing field, using the left and middle mouse buttons.

Play around with the colours until you feel happy with the controls. Try to mix a pastel green colour, or something else if you prefer. Render the test ball again to see the changes you have made.

Material properties

A material consists not only of colour, but also of *light emittance properties* such as shininess, mirroring, etc. You can see the material properties of "porcelain" by looking at the sliders at the top right. More importantly, you can change these to make your own variation on the material.

There are over 16 million colours available!

It's often a good idea to put black and/or white in some corners.

The meanings of the different sliders are explained below. Try moving them, and render the material on the test object after each change to see what effect they all have. It's worth spending some time at this stage to get a good feel of the way these properties interact, as they are crucial to the creation of realistic images.

Don't mind if your material starts to look funny as you experiment – you'll get a chance to cancel your changes later.

Ambient

Ambient light describes a constant brightness for the whole surface. You can think of it as *"day light"* which comes from all directions, independently of the user-defined light points.

Try what happens with the extreme values 0.0 (no ambient) and 1.0 (lots of ambient).

Usually, give a material some ambient light: otherwise, light points result in completely black shadows. However, *avoid using it with glass and mirror materials* - they easily become over lit if you add the ambient component.

Diffuse

The **diffuse reflectivity** value describes the general reflectivity of the surface, *i.e.*, the overall effect of light points. A low value means a dark object, a high value, a light one.

Diffuse reflectivity does not affect highlights. They are controlled separately, with the following two sliders.

Specular

The **specular reflectivity** factor describes the polish of a surface, *i.e.*, *brightness of highlights*. The greater the value, the brighter the highlights and the shinier the surface appears.

Hardness

Hardness describes the *highlight sharpness* (size) on the surface. For soft materials, use values near to zero, and for hard materials larger values.

With very large hardness values (close to one), the highlights may become so small they don't show on the test ball at all. They will show on a larger picture resolution, though.

Bump

The **bump** parameter makes the material have an irregular surface, not perfectly smooth. This is a very useful effect on many occasions, as real world rarely behaves so regularly! Try different values between zero and one.

Mirroring and reflectivity

The material can be made **mirroring** or not by clicking at the corresponding YES and NO buttons.

The **reflection factor** describes how much the object mirrors other objects. Value 1.0 describes a perfect mirror, while smaller values make the material reflect the environment only dimly.

Remember to *use a low ambient value* with mirroring materials.

Glass

Make the material appear transparent like **glass** by clicking the glass: YES button.

Mirroring does not have much impact on glass, so you should usually set it off. If you have mirroring on, however, use a *low reflection value* – an object cannot simultaneously show through and be a perfect mirror.

Refraction and transparency

The glass behaviour is controlled by two properties: a factor that controls **refractivity** - how the light is *bent* as it passes through the object, and another that controls **transparency** - *how much* the object shows through.

Glass normally has a refraction factor between 1.2 and 1.4. Values below one are rarely needed, unless the object is made of a material thinner than air.

If the glass is highly transparent, and mirroring at the same time, remember to *use a low value on mirror refractivity*. Otherwise the object gains too much light!

Cancelling material changes

Obviously if you have moved the sliders a lot the material won't look very much like porcelain anymore! In this case, you may click the UNDO button in the middle. It cancels all the changes you made to the material, including colour selection, since the time you last selected a material for editing.

If you have for some reason selected another material during the editing session, and wish to go back further than to the last selection, you could reload the "porcelain" from the material library. Since you have already loaded "porcelain" before, use the REPLACE button this time instead of LOAD.

You now know how to define materials.

If you have edited several materials, and wish to cancel all the changes to them, you may exit the material palette by clicking at the CANCEL button at the bottom right. However, this works only if you haven't already assigned materials to the objects – as we are going to do now.

Applying a texture

The bottom left corner field of the material editor allows you to try a *solid texture* over the surface. This isn't really appropriate here but let's get radical for a while - how about a porcelain marble coffee pot!

To apply a marble texture:

1. Click on the name "marble" in the TEXTURES list.

   Render the test image to see the texture.

2. Change the X, Y or Z sliders.

   Render the test image to see the change.

3. Click on the VEINS button. Then point at the "default" material box in the current material's window.

   Render the test image, and see how the marble veins change to the default material's colour.

4. Don't like a marble coffee pot? Select "`marble`" from the texture list again to inactivate it.

Actually, DESKARTES treats textures separately from the materials. A texture is not considered to be a material property, but rather a picture painted on the object. Textures like marble can be *shown* with the material palette, to check how they appear, but *not assigned* to objects.

Assigning materials to objects

You should now have defined the porcelain material for the coffee pot. But how does the system know it belongs to the coffee pot, and not the bottle for instance? You need to *assign* the material to the surface.

Notice the object window is still visible on the screen. You may use it to select objects during material editing.

Select the `pot` element. Then click on the wide `ASSIGN` button in the middle. This transports the currently selected material to the object selected from the object window.

We already assigned the "glass" material to the bottle in Lesson 4, but you could now make it more interesting with a `bump` factor of, say, 0.2, and less `transparent` using a factor of about 0.9.

You know how to assign different materials.

The material name "glass" is already assigned to the bottle. You don't have to assign it again, but it won't cause any harm if you do.

The cap is still made of "default" material. Edit it any way you like, and assign to the `cap` when ready.

Exiting the material editor

When you have set and assigned all the materials, you will want to close the material editor. Click OK at the bottom left.

Texturing

Now the materials are all set, let's define a textured label on the bottle. You'll place a picture of the DESKARTES logo on to the bottle by ***texture mapping***.

Textures are defined as ***texture areas*** on the surfaces. A texture area may cover the whole surface or just a part of it. It also holds the information on which image to apply for the texturing, and how to position the texture.

Reading a library image

Before you start with texturing, go and see what the logo looks like. The following explains how to ***view a file*** under DESKARTES's texture library, the directory DA_textures, without moving from your current model directory:

To see a library texture:

1. Pop up the file window.

2. Move the cursor to the *right hand field* of the file window. Press the *middle* mouse button to get the menu appear.

3. Give the command HELP DIR: SELECT.

4. Click at the DA_textures directory in the left hand field. Its contents then appear in the help directory field.

5. Select the file tex_DAlogo.pic.Z from the right hand field and give command HELP FILE: READ.

6. Move the cursor to the image and click "q" on the keyboard when you've seen it.

Texture mapping

Now to place the logo on the bottle. In this case, the texture consists of an image on a part of the surface, but the following procedure would similarly apply to many other texturing application, as well.

To define a texture:

1. Select and display [f] the bottle surface.

2. Give the command TEXTURE⇒ Area: Create New.

3. Tell the system to apply colour image texturing.

4. Tell the system that "DAlogo" is the name of the image.

   Note the other options!

   Define the texture's material as "default", which happens to be a suitable glossy material for a paper label.

   To define the texture of the surface's own material, you could just leave the material field empty.

   Using the replication parameters you could produce multiple copies of the texture, like flowers on a wall paper. But don't use them now.

   Blurring smoothes out the texture, so that it's individual pixels won't show so sharply. Use it if you like.

   Adaptive mapping minimises the distortion of the texture as it spreads on the surface. It should normally be applied, so click YES on it.

Leave `transparent background` to `NO`. This way only the logo will
be shown on the surface with it's own background colour.

Finally, click `OK` to accept the chosen parameters.

5. In the next dialogue box select the parameter option `corners`.

6. Click at the lower left and upper right corners of the desired rectangular
    area on the surface, where you wish the image to appear.

A rectangle with an arrow inside appears on the surface. The arrow in the box
should go from left to right across the bottom of the box as below:
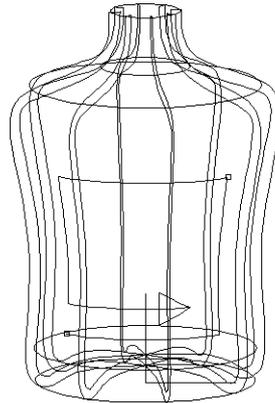
You might want to complain that the sides of the texture area aren't straight. But
don't worry, we could manage that by *projecting* the rectangular label on the
surface, as will be done later in Lesson 15.

If you made a mistake in placing the texture's corners, you may change it to new
position and size using the command TEXTURE⇒ Area: Placement. To check
the other parameters, texture name etc., use the command TEXTURE⇒ Area:
Parameters.

GLWindow:Camera View *mode*

You would probably like to render the objects with their new materials and textures.

Remember that GLWindow:Shaded View, which we have used so far, is the lowest level of shading available within DESKARTES. It only uses one light point, it simplifies the material definitions, it does not display textures, and does not attempt to render mirroring effects.

There is a higher level of shading called GLWindow:Camera View. Among other things, it shows the materials more accurately than the default mode, and displays one texture, too.

You should be aware, however, that render just quickly computes a *preview* of the final image! Render does not treat the models accurately; instead, it approximates them with small facets. It also makes simplifications when showing the textures, and it is not able to render true reflections or glass material at all.

All of these things could be accurately rendered with ray tracing, as you'll learn later. First let's see what Render can do for you.

Starting the Complete mode

Start Render now, as follows.

Starting Render:

1. Display [y] the objects you wish to render. View [v] and zoom [z] the model as you want it to appear in GL.

2. Give command SCENE⇒ Camera: Match Eye, and specify 30 degrees as the view angle. This places the objects in GL initially to your current viewing direction and size.

3. Give the command RENDER⇒ GLWindow:Camera View .

The GL menus and interaction work just the same as you've learned with the default mode, you may rotate the image, etc.

Defining a background image

To give a taste of what more advanced things you can do with
`GLWindow:Camera View`, add an image to show in its background.

To define a background image:

1. Give command `SCENE⇒ Define: Backg Type`.

2. Tell the system to paste a `texture` in the background.

3. Give name "sky" for the background texture. An image with such a name will be found in DESKARTES's texture library.

To see the image, give command `PREVIEW⇒ GL: Complete` again. It shades the scene, complete with the background.

Shading accuracy

You may notice as you rotate the objects around in the window, at times some of the curved sides of the model look polygonal, not smooth. The high lights should also be sharper than they appear. These defects are due to *faceting*.

In render the surfaces are broken down into a series of flat triangular surfaces, facets. This enables the speed of real time rotation to be achieved at the loss of some realism. If the faceting effect is too pronounced you can improve it at the cost of real time speed - the choice is yours.

To improve shading accuracy:

1. Select the command `Preferences` in the `RENDER` menu.

2. Change the `accuracy` setting to `fine`.

3. Start `RENDER`⇒ `GLWindow:Camera View again.`

You should see a reduction in the amount of faceting but will probably find the rotation speed slightly slower.

Saving the file

Save this file, so you can continue to use it in the next Lesson.

To save the model:

- Select `FILE: WRITE` in the file window, select `model (geom_)`, and accept `collection`.

Lesson 13 : Lights! Camera ! Action!

In this Lesson, you will learn how to set up the camera and position various kinds of light sources using the scene editor. The exercise continues work on the `collection` model.

The scene components

Creating a computer-generated picture is easy - creating a *realistic* computer generated picture can take much more care. It helps if you have some flair for composing a picture as the operations you need to perform relate directly to photography. In fact DESKARTES takes the analogy a little further by allowing you to position an electronic camera and lights around your model in the scene editor. Before we do this let's just define what is meant by the terms camera and lights.

Camera

A *camera* in DESKARTES is the object that determines what you see in the shaded picture. This is generally different from the *eye point* that we have used for viewing the objects as wire frames during modelling work.

This may seem an unnecessary complication, but just consider. When you are creating the model, you judge it with your own eyes, just like manual design! When the design is finally ready, you would take several photos of it from different angles to show it off to its best - you need to position the camera for each picture, along with the associated lighting positions. In other words, you need to define several *scenes*.

So a camera defines what you see in a picture. To do this a camera has a *position* or location, a *viewing direction* and a *viewing angle*. As you will soon see you can control the position of the camera interactively on the screen. The viewing direction is controlled by a target to which the camera points, it defines the centre of the picture. Just like the camera position, you can control the position of the target interactively in DESKARTES. Finally, the viewing angle determines the extent or

limits of the picture, often known as the field of view, and guess what, you can control it interactively in DESKARTES.

Remember though if you position the camera very close to the object with a wide viewing angle you will see the same extent of your model as if you position the camera further away with a narrower view angle. The difference between the two pictures is the *perspective*. The close up camera position will generate a much stronger perspective effect than the distant camera and may make your picture appear distorted.

To summarise a camera has a position, a target point and view angle.

Lights

There are two types of lights supported by DESKARTES. **General lights** emit an equal amount of light in all directions. **Spotlights** emit a cone of light in a specific direction. Outside of this cone, the light has no effect.

DESKARTES allows you to position your lights (as many as you like) around the model. For spotlights, you can also position the target point just like the camera. Finally, lights can be assigned a *colour and intensity*, which may be different with each light.

The scene editor

So let's set up a scene. Load in the `geom_collection` file we created in the previous Lesson and run the *scene editor*.

To start the scene editor:

1. Display the surfaces using DISPLAY⇒ All: Fit [y]. This defines what will be shown in the scene editor.

2. Issue the SCENE⇒ Camera: Light Edit command.

3. A dialogue box appears asking if you want to move the camera to the current eye point (remember the difference?). Answer NO, as you just matched it in the previous Lesson.

You will see the camera pointing to the model right from the eye direction, and one light point in its current location. The camera and the light are drawn with a vertical "plumb" line, which drops down on to the floor, to help you visualise their position.

You'll also see a new set of icons, which describe the functions available in scene editing mode. You are ready to set the scene for a picture.

Selection

This icon allows you to *select a scene item* – the camera or a light point – to manipulate it in some way.

To select an item:

- Point at the item on the screen and click the *left* mouse button.

The currently selected item is drawn in white. At this stage, select the camera ready to reposition it.

Moving

These functions allow you to *move the selected item* on the screen. They constrain the movement either vertically or horizontally.

Try the following operations to move both the camera and the light to new positions.

To move an item:

1. Select the item you want to move.

2. To move horizontally - Click near the currently selected item with the *middle* mouse button and hold the button.

   To move vertically - Click near the currently selected item with the *left* mouse button and hold the button.

3. Move the mouse and the item follows.

4. Release the button when the object is positioned to your satisfaction.

Before you continue, make sure the camera and the light are positioned to the same side of the scene. Otherwise, the light will fall on the back of the model, and the camera side will appear dark.

Viewing the picture

This function *displays the model as wire frames*, showing you exactly what the camera sees of the scene.

After checking the camera view, you may click any mouse button to return to the normal viewing mode.

If the item you have selected is a spotlight, the **v** function shows what the light sees of the scene. This is a very useful tool!

Shading the picture

This function *shows the scene shaded by software.*

Software is able to render textured surfaces better than GL.

Try software shading now, and click a mouse button when you've seen the picture.

Seeing the changes GL shaded

The **g** function calls for a GL window to render your scene changes in real time.

As you move or otherwise manipulate the scene items, the changes are immediately updated in the GL window. Keep the GL window on screen during the following scene editing session.

Zooming and panning

As you have the GL window covering a large portion of the screen, or for some other reasons, you might like to *zoom and pan* the image to see the scene items. For this, use the **z** function just like in all the other edit modes.

Shading the picture in GL

The GL window is normally updated only after each of your changes is complete, that is, as you release the mouse button after moving. However, if you give the **G** function – after having started **g** – all changes will be rendered immediately as they happen, *during the mouse movement.*

Be warned: using the **G** option will be quite jerky if you are not using a reasonably powerful workstation. To turn off the continuous updating mode, click on **G** again.

Adding another light

You currently have only one light in the scene but you can add more if you like. Click on the add light icon or press **n**.

A second light appears on the scene. Move it to another position if you wish.

Setting the positions

This function is available to *numerically* set the camera or light positions, view angles and target. It is particularly useful in architectural and other applications where you wish to have exact control on these. Try it to check how the camera is currently defined.

Spots and coloured lights

You should now have two lights in the scene. They are currently both general lights. You can alter the properties, to make one a *coloured spot light*, for example.

Select a light point, and select the **l** function. Make the light a spot light. Give the light a bluish colour, using rgb values red: 0.5, green: 0.5 and blue: 1.0, for instance.

Coloured lights often make things a lot more interesting.

Note that the light is drawn differently to indicate it is a spotlight. It now has a target point, just like a camera, which can be selected and moved to control the light direction. The angle of the spotlight can also be altered by using the view angle function. See the next two functions!

Altering the view angle

This function allows you to change the *field of view* of the camera so that you will see more or less in the picture. It can also be used to alter the *angle of a spotlight*, if you have one selected.

Try the following first with the camera.

To alter the camera view angle:

1. Select the camera.

2. Click at the view angle icon or press **a**.

3. Press and hold the left mouse button.

4. Move the mouse up or down to increase and decrease the camera view angle

5. Release and mouse button to set the view angle.

Try the same function with the spotlight, as well. Check the spot view using the **v** function.

Altering the camera target

This function *moves the target point of the camera or a spot light.* The movement happens just as moving the actual items: middle mouse button moves the target horizontally, and right button vertically. Try it with the camera.
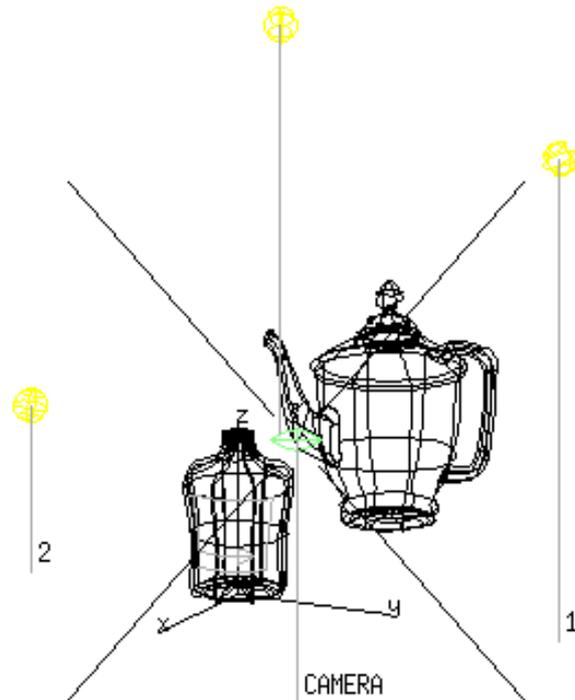
Deleting a light

This function *deletes the selected light.* Use it if you don't like the spot light effect, for instance.

Exiting scene edit mode

You have learned to set up a scene.

Use the functions until you create a scene that you are happy with. Don't mind if the picture doesn't really match your artistic standards – remember it's just your first experiment, and we'll keep adding detail in it later on.

Exit from the scene editing with **w**. This way the changes you made to the scene will be saved. To discard your changes, you could use the **q** function and start over again.

Scene editing in four views

Before you continue, see also what scene editing feels like in *four views*, if you have the settings window button `AREA: four` selected. You'll probably find out this is the way you want to do your scene editing in the future!

Ending the Lesson

Now you now most of the various scene editing possibilities. To end the Lesson, save your work again into the model file called `collection`.

Lesson 14 : Time to press the shutter!

PreViewing generally gives you just a simplification of the image. It is fast, but it cannot render true reflections or glass, among other things. The technique used to calculate the final picture is known as *ray tracing*. It is a very intensive operation but one that produces extremely effective results. The ray trace module of DESKARTES is called ExTrace.

Continuing with our analogy to photography, you are now in the position to press the shutter release to take a picture. With a real camera, this would take only 1/60th of a second or so. With a computer-generated picture, the wait is going to be a little bit longer. This should not be surprising to you since the computer doesn't have a physical model to work with. It only has a virtual, electronic model. However, you won't have to wait all that long to check your picture is what you wanted – DESKARTES makes even ray tracing a very interactive procedure!

Continue with your `collection` model.

Starting ExTrace

You'll first render the image just as it is defined now. Later you will continue adding detail until you are perfectly happy with it.

To start ray tracing:

1. Start ExTrace with the command EXTRACE⇒ `Start/Update`.

2. A dialogue box appears. Make the size for the image 600 by 600 pixels.

   You want to ray trace everything currently shown on the screen, and use the camera position you just defined with scene editing, so accept the other parameter options as they are.

3. The ExTrace window will start to show a picture of the scene you have just defined. At first the picture will be quite crude - made up of large blocks.

   The image gradually refines and the blocks (*macro pixels*) become smaller. This way you can quickly see the picture to ensure that everything is all right.

4. Click `Stop` in the ExTrace window to interrupt when you have seen enough. You are then able to continue with any changes you want to make in the picture.

Defining the floor

To make the scene more realistic, add a `marble` floor underneath the models.

To define an ExTrace floor:

1. Give command EXTRACE$\Rightarrow$ `Insert: Floor`.

2. Select `marble` from the dialogue box.

3. Enter `densities` of 5.0 in the next dialogue box.

   These define how small or large the marble pattern is. The larger the density values, the denser the veins.

4. The marble will consist of the materials and colours you have previously defined with the material palette – change them now if you like.

ExTrace waits to see if you have some other changes in mind, it didn't automatically update the picture when you inserted the floor. So give command EXTRACE$\Rightarrow$ `Start/Update` again. Interrupt with `Stop` after a while when you see the picture clear enough.

Zooming and panning with ExTrace

Try a couple of *graphical interaction* options with ExTrace.

You might want to see part of your image in more detail, so make the picture "tighter":

To zoom into the ExTrace image:

1. Give the command EXTRACE$\Rightarrow$ `Locate: Zoom`.

2. In the ExTrace window, press *and hold* the left mouse at the middle of the picture area you wish to get zoomed.

3. Move the mouse and release the button. The picture begins to update automatically.

4. To zoom out in the ExTrace image, repeat step 1 and *click* the *right* mouse button.

Try also panning the image:

To pan the ExTrace image:

1. Give the command EXTRACE⇒ Locate: Pan.

2. Press *and hold* the left mouse button at a point which you wish to move.

3. Move the mouse to the place where you want the point to move and release the button. The picture begins to update automatically.

Scene editing with ExTrace

Now change the ExTrace picture using the scene editor, and see the changes updated in the ExTrace window as they are done!

To scene edit with the ExTrace image:

1. Stop the rendering operation in the ExTrace window.

2. Give the command SCENE⇒ Camera: Light Edit.

3. You are asked if to match the camera with eye. Answer NO if you want to continue from your zoomed ExTrace view, or YES if you wish to return to the original wire frame view.

4. *Iconize* the ExTrace window, to remove it temporarily from screen.

5. Move, add or delete the light points, and move the camera as you wish. If you don't remember how, refer back to scene editing.

6. Select the **e** function to see the changes with ExTrace. The iconized ExTrace window pops up and starts to render. Click on `Stop` when you've seen enough.

7. Repeat 5&6 as often as you like.

You've done interactive ray tracing!

8. Leave scene editing by pressing **w** (or **q** if you got lost).

Batch processing the image

Finally, when you have finished experimenting, and are happy with the picture, compute it as a ***background (batch) process***. Give command EXTRACE⇒ `Render: Batch Process`. Accept the parameters as they are.

This will start to render a high quality image in the background, while you can continue your work. When launching the process, you could also have told DESKARTES to start the computation only after so many hours, so that it wouldn't occupy the computer resources at the time you are working.

Don't start several batch processes at the same time - they would slow down each other.

You can continue making any changes to your image, and start them as other batch processes. Each batch process will produce an image just as it was defined when you launched it, even though the actual processing would start later on.

Continue working with ExTrace as long as you like. Finally, when you are ready, give command EXTRACE⇒ Done.

Reading the picture file

When the background process is started, a file called `expic_myscene.1.rgb` appears in your model directory. You may load it onto the screen to see how far the computation has reached.

Load the file by selecting it and give command `FILE: READ` in the file window. To remove an image from the screen, move the cursor in the picture window and press "q" on the keyboard.

When the background computation has finished, two files called
`expic_myscene.1.rgb.Z` and `expic_myscene.1.pic.Z` appear in your
model directory. The first one (`rgb.Z`) is the completed image in full 24-bit
colours, and the second one (`pic.Z`) is the image reduced to 8-bits. According to
your monitor's colour resolution, load one of them on screen to see the completed
picture by double-clicking on the name in the file window.

By the way, when you see the image in full resolution you will probably notice that
the "sky" background looks more like "snow". The background texture is too small
for the ExTrace image, so its details get expanded – the clouds turn into snow
flakes. To get a better sky effect, you should apply a larger texture image.

*You now
know how to
batch process
ExTrace
images.*

Saving the work

Congratulations! You now know all the essentials about materials, textures,
cameras, light points, and ray tracing, and how to work with them together.

The model is now complete, for the sake of this Tutorial at least. Remember,
however, to save your scene definitions into the `geom_collection` model file, as
always when you've done something worth keeping!

Lesson 15 : Painting on the Model

In the final Visualisation Lesson, you will learn how to create your own textures using a simple *painting* program. You will design your own texture image and map it on the *complete* coffee pot model, not just on a single surface as previously.

If necessary read in the `geom_collection` model.

External graphics

Last time we used texturing, in Lesson 12, we mapped an already existing image – the DESKARTES logo – to the bottle surface. This is the most typical way of applying graphic designs with DESKARTES created models: you obtain them from "somewhere", they may be provided to you on a floppy, produced in some painting program, scanned from a photo, or whatever.

Any images from other systems and devices may be applied as DESKARTES textures, as soon they are *loaded in your model directory* in DESKARTES's database. The images must be presented in *TIFF, RGB or the Sun Raster File (PIC) formats.* The file window command FILE: CONVERT provides the most general alternatives to *convert images* from one format to another.

Using TextPaint

But you don't have to use pre-defined images, instead, you can design an image of your own. Try **TextPaint**, DESKARTES's **painting program**.

To start TextPaint:

1. Give the command TEXTURE⇒ Image: Paint.

2. The program asks you if you wish to *include* the current image into the drawing, use it as a *template*, or erase the screen before you start painting. Choose the last option.

After a short while, the painting *toolbox* icons appear. There are four toolboxes and a colour chart. Click on the toolbox icons to see the tools. You can hide them by clicking at the toolbox icon again: when working, it saves space to show only the tools you need at the current time.

Try some of the tools, just to get the hang of them. At this stage it doesn't matter what or where you draw.
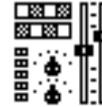
The controls' palette

The way the different tools work depend on a number of adjustable factors, such as pen and spray sizes, the zooming factor, the active drawing colour, and font type and size. They may be set with the sliders and buttons in the *controls' palette*.

For the moment just accept the factors as they are.

Colour chart

TextPaint has 256 colours available at a time. The available colours are shown in the *colour chart*. You can select your drawing colour by clicking it in the colour chart with the *left* mouse button.

Selecting with *middle* mouse button from the colour chart has a different meaning. It *opens the colour*, and pops up the *colour palette* where you can select any new colour to replace the old one. Try it and see!

You can also choose a *colour from the image* itself. Point at the image, and select the colour from there with the *middle* mouse button.

You may use these colour selection functions *any time* during the following painting session.

General drawing tools

The **general toolbox** contains the most commonly used tools for making graphics. Open it now.

The tools are operated very much like the other DESKARTES's controls you have already used. They don't have shortcuts, though, as painting is most naturally done using the icons directly.

Using TextPaint functions:

1. To see brief explanations of the functions in the message lines, you may click on the icon with the *middle* mouse button.

2. To start a function, click on the icon with the *left* mouse button.

3. Use the function you've selected. You may change the colour, adjust the pen size, etc., while executing the function.

4. To end the function, click the *right* mouse button, or just select a new function.
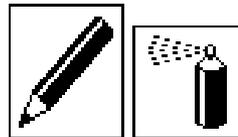
Pen and spray

Practice a while with the above functions (*pen draw and spray*). Try also changing the pen size and colour from the controls' palette as you work.

The eraser

The eraser function works like pen, obeying the pen size, too, but it *wipes out* things you've painted.

Fonts and text

Font selection and typing text may be done with the above functions. *Change the font* from the window which pops up with the letter icon, then *type text* into the picture using the typewriter icon.

Notice the text appears in the selected drawing colour. You may change the colour, even in the middle of typing.
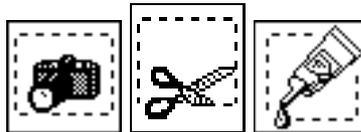
Copy, cut and paste

The camera icon (*copy*) copies the area you select onto an invisible *"clipboard"*. The glue icon (*paste*) pastes whatever is on the clipboard into the selected area. In other words, you could make a copy of an area with these two functions.

The scissors icon (*cut*) works just like copy, except that it erases the selected area, "cutting it out" into the clipboard, from which it can be pasted back in.

Zooming

This function allows you to zoom into a part of the picture, and *edit it pixel by pixel.* The changes are seen in the zoom window and in the actual picture, too.

Colour selection from image, with the middle mouse button, is extremely useful with zoomed images. Try it to match the values of some neighbouring pixels.

Notice also that you can enlarge the zoom window on the fly by grabbing it from the lower right corner.

Cancelling

If you make a mistake and wish to cancel something you just did, press the cancel icon (the backwards running clock)

... or to start drawing the whole image again from scratch, use the "graveyard" icon.
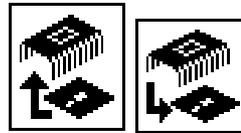
Read and write

The *read* function ("from disk to chip") allows you to load in an already existing image. The image may be an ExTrace picture, a texture image, or whatever. You may use any of the available functions to change it, *retouch* the image by zooming, adding text into it, and so on.

The *write* function stores your TextPaint image (back) into file. Don't use it just now, unless you've created something definitely worth keeping.
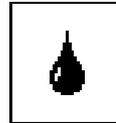
Flood fill

Finally notice the *Flood fill* function. With it you may fill closed areas of the picture with the selected colour or pattern.

Flood fill not only fills the area, but it widens it by the factor of the pen size, too (just like "real" ink!).

Use flood fill to colour the insides of the primitive elements, in the following.

The primitive tools

The primitive tools are used to create *standard primitives*: elements made of straight lines or arcs, such as rectangles, polygons, and ovals. Try them.

Stipples and tiles

These tools make it possible to select, create and edit different kinds of patterns to be used when painting with the other tools. Let's leave them for later practice, however.

Exiting TextPaint

Finally, exit TextPaint by clicking at the Smile icon. The system notes you haven't saved your artwork and asks if you want to exit anyhow. Answer YES, you'll get a chance to create a more useful painting in just a while.

You've learned to use TextPaint!

Bounding plane texturing

When you have finished experimenting, it is time to produce a real pattern that flows down the spout of the coffee pot across the blend onto the body.

Since the texture stretches across several surfaces, a special technique is required. We won't apply the texture separately with the different parts of the coffee pot – it would be impossible to make it flow from one surface to another that way. Instead, it will be defined on another **bounding surface**, in this case a *plane*, from which it

will be *projected* onto all the coffee pot surfaces. This ensures that the texture matches up perfectly across the boundaries of each surface.

Painting on a template

To create the texture, you'll paint the picture to the correct position on the coffee pot.

Set the viewing direction to the side of the model with Settings⇒ X and display [f] the coffee pot surfaces, using DISPLAY⇒ Fit [f].

Then start TextPaint again (command TEXTURE⇒ Image: Edit). As a parameter, specify you wish to use the screen contents as *template* for your graphics – you'll paint on top of the coffee pot!

Using the TextPaint functions explained above, create a simple picture such as the ugly one shown below.

When you are working, it may happen that you erase parts of the template and wish to *refresh* it. This may be done with one of the TextPaint menu commands: use the command PICTURE⇒ Refresh Object from the menu bar.

When you are ready, store the image into a file:

To store a part of the picture:

1. Click on the "write file" icon

2. A dialogue box appears, asking for an image name. Type mydesign.

3. The dialogue box also asks whether the whole screen should be stored, or just a part of it. Choose the option called free select.

4. Choose the desired area using the cross-hair which appears, first clicking at the lower left corner, then at upper right.
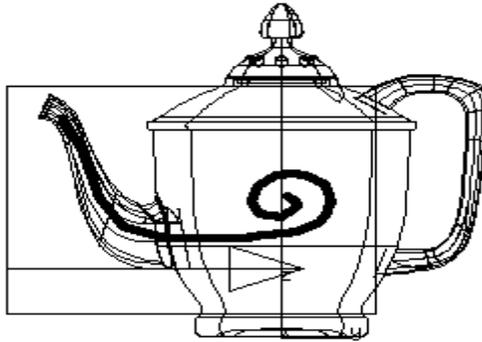
Creating the bounding plane

Now map the texture to the coffee pot.

To define a bounding plane texture:

1. Give the command TEXTURE⇒ Bounding: Plane.

2. The systems asks you the name of the texture image. Type "mydesign".

3. The systems asks you to draw the plane. There is a special option available here, so use it:

   Click on *any key on the keyboard*, not a mouse button. Confirm what you just did by clicking the *left mouse button* now.

   This way the system understands that the plane should be *exactly the same size and shape as the image you last saved from TextPaint.*

4. In the next dialogue box, you must give a name to the bounding plane, so that the actual surfaces may find it. Use any name, for example "plane".

   You must also tell what kind of texturing, and which image to apply. This happens quite like in our earlier example with the logo: select colour image texturing, then "mydesign" to the texture name, but now click YES on transparent background - *you only want the painted parts to show!*

The texture is there. Change the eye point back to 3D to see the plane. This is just a very special case of using bounding objects for texturing, but a very effective one, too.
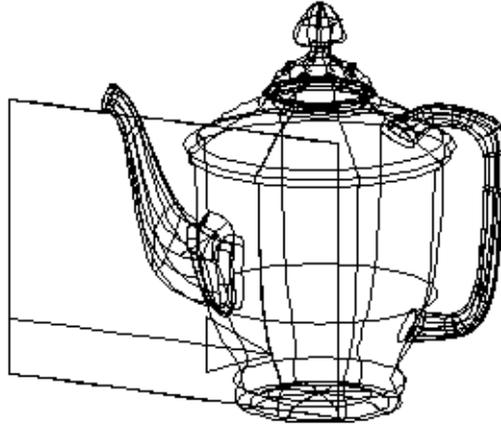
Do you now see how you could have applied this method with the label on the bottle, to make it square? More generally, you could design the bounding object to *any shape* you require, *e.g.*, curved to follow the coffee pot more closely, and project textures from it to other surfaces in various ways.

Ray tracing the model

You know how to use bounding planes.

To see the results of your efforts, start ExTrace and render an image of your finished masterpiece. Let's also once more play with the ExTrace background colours, to make the picture a bit more interesting.

Eye view

To get right to the point, don't go to scene editing or other fancies this time. Just define a suitable view using [v] and [z], then start ExTrace with EXTRACE⇒ Start/Update using the parameter option match camera with eye.

Sliding background

Interrupt the ExTrace computation with `Stop`.

Give command `SCENE`⇒ `Define: Backg Type`, and select the option `sliding colour` from the dialogue box. Render the scene (`EXTRACE`⇒ `Start/Update`), and see how the background colour changes from light at bottom to dark at the top.

Background colours

Interrupt the ExTrace computation, and try command `EXTRACE`⇒ `Locate: Backg Colours`. Then click in the ExTrace window at the horizontal level where you wish to define a new colour. A portion of the material palette, the *colour palette*, shows up. Select any colour you like.

Give command `EXTRACE`⇒ `Locate: Backg Colours` again and select another colour. Place it to another level in the ExTrace window. Finally, render the image with `EXTRACE`⇒ `Start/Update` to see what you've accomplished!

Congratulations! You have completed the Visualisation Part of the Tutorial. You should now know DESKARTES well enough to start designing on your own.

Play with the system to create real designs, modelling and rendering them with the techniques you've learned. You should still have most of the Tutorial exercises fresh in mind, so you'll easily find example instructions when you need them. Glance through the Contents section to review what you've been through!

Proceed to the final Tutorial Part after you have practised a while with the standard techniques, and want to learn more …

PART IV: ADVANCED MODELLING

This Tutorial builds on the Modelling Principles Part of the Tutorial. It is anticipated that before progressing to this advanced stage students have completed and fully understood all aspects of the previous Tutorial Parts and will most probably have spent some time consolidating the skills they have learned by working on their own designs.

The style of this Part is intended to be much brisker with little explanation of the basic techniques already covered elsewhere. If you find yourself having difficulty with the following, obviously you should refer back to the earlier Tutorial.

Several advanced topics are covered by means of four Lessons. All Lessons continue to use the basic modelling exercise of the coffee pot and bottle.

Lesson 16 : Working with Trim Curves

In this Lesson, you will continue to work on the coffee pot model concentrating on the area of the blend between the spout and the body.

Rolling ball blends - review

You should now have DESKARTES running with the geom_coffee file loaded. Firstly review the hierarchy of the model. It is made of five elements, body, handle, spout, lid and pattern. The element body contains a rotational surface. The spout contains a built surface and the blend surface. Both the rotational surface in body and the built surface in the handle own trim curves.

Do you remember how you made the blend originally? The command used was TRIM⇒ Blend: Rolling Ball. This required you to have the first surface selected and then to pick off the screen the other surface to be blended. You may also remember that the normal directions of the surface influenced exactly which of four possible blends was produced. In this case we had to ensure that the blend was created outwards from the body and the spout.

Upon completion of the blend we also showed how the blend could be re-shaped. Using the TRIM⇒ Blend: Reshape command two numbers could be specified in the range 0-1 which controlled the influence of each surface on the blend. Using these, we could vary the normally circular blend, even to the point of creating a chamfer.

Deleting a rolling ball blend

How would you now delete the rolling ball blend? Easy, you think: I simply make the blend surface the target object in the object window and issue the OBJECT⇒ Delete [k] command. Try it and see!

The rolling ball blend surface is in the spout element. It is called Surf/Bz/blend.

To delete a blend surface:

1. Select the surface to be deleted.

2. Issue the command OBJECT⇒ Delete [k].

3. Select another surface and DISPLAY⇒ All: Fit [y] to show all
   remaining surfaces on the screen.
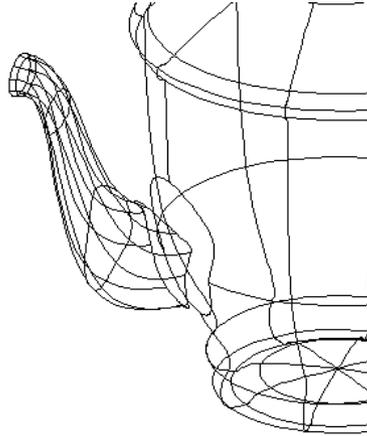
Not quite what you expected? Part of the handle is still missing and there is still a
hole in the body! Why? Stop and think and you can work out the reason. What cuts
out parts of surfaces? Trim curves!

Look at the body surface in the object window. This surface doesn't own one set of
trim curves. It actually owns three. Why? The names of the three trim sets give you
a clue.

1. One is called `..TRIM/handle`. It is the result of the intersection
   operations with the handle element. It holds all of the curves to trim the
   two holes where the handle attaches.

2. Another is called `..TRIM/spout`. It is the result of the blend operation
   with the spout. The curves it contains effectively cut a hole in the body for
   the spout.

That's it then – all I need to do is delete this set of trim curves (`...TRIM/spout`) to restore the body to its original state, you think. Try it.

To delete a trim set:

1. Click on the trim set to be deleted. In this case the one called ... `TRIM/spout` in the `body` element.

2. Delete `[k]` the trim set.

3. Click on a surface and [y] to show it on the screen.

Wait a minute! The hole is still there. What is going on?

DESKARTES is clever enough to keep a ***historical record*** of the trim operations that have been performed on a surface. What you just deleted was a historical record, but they do *not* themselves trim any surface.

Instead DESKARTES combines all of these historical records into one ***actual trim curve set***. This is the first trim curve set after the surface, called `−>TRIM/merged`. It is this one that contains the curves that actually do the trimming.

We deleted the historical record of the trim operation with the handle blend, but DESKARTES doesn't automatically update the trim curve set. So how are we going to get the surface to recognise that history has changed? By using the correct command of course! Try the following:

To update the history of a trim set:

1. Click on the surface for which trims are to be updated, in this case the surface `Surf/Bz/Rotate` in the body element.

2. Issue the command TRIM⇒ `Change: Merge Trim Sets`.

3. Select the body surface and to show it on the screen.

Finally the hole has gone from the body surface.

You need to perform the same operations on the spout as well. In this case the spout has only had one trim operation so you could simply delete this trim curve set.

You could now blend the surfaces again. In summary:

To recompute a blend:

1. Delete the blend surface.

2. Delete the trim curve set for the blend from each surface involved.

3. Update the trim sets for each surface.

4. Blend the surfaces with new parameters.

Trim curves for the technically minded

Some readers of this Tutorial may be interested in what trim curves are and how they work. Others may be very happy to just use them in their models - you can quite happily skip this bit now if you wish.

Start fresh with the original geom_coffee model again. Click on the trim curve set immediately below the surface in lid element DISPLAY⇒ Object: Fit [f]. You will see something like the picture below.
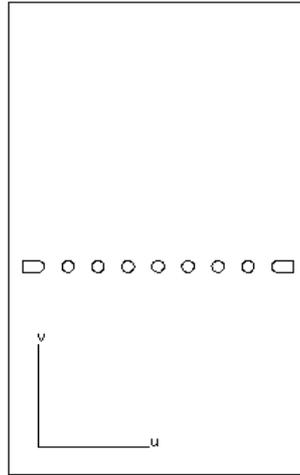
What you are seeing is the *parameter plane* of the surface. The easiest way to think of this is to image the surface to which the trim curves belong flattened out to form a rectangle. The perimeter of this rectangle is formed by the first curve in the trim curve set.

If you look in the bottom field of the object window you will see 4 or 5 polygons. The remaining polygons form the holes for the handle and spout. They are not the same shape as the cut out holes since the surface has been distorted in the flattening process to form a rectangle.

But how does DESKARTES decide whether it is a hole in the surface or actually part of the surface? Imagine the rectangle as a *field* and the polygons as fences which guard *lakes*. The lakes may further have *islands* in them. There could even be more lakes in these islands, and so on.

If a man were standing somewhere in the field and were to walk across this field he might have to climb over the fences. If he were to count the number of fences he had climbed over he could determine whether or not his feet were wet! If the number of fences climbed is *even* then he was originally standing in a lake – *i.e.*, that surface part was cut out. Try it on the diagram above - don't forget the "fence" right around the outside of the "field".

Note that DESKARTES only considers *closed* poly<u>gons</u> in this process - *open* polylines are ignored (the water from the lake would run out!). You may have come across the command TRIM⇒ Change: Invert Cut Part that swaps the part of a surface trimmed away. Try it on the body surface now, noting the change that occurs in the trim curve set:
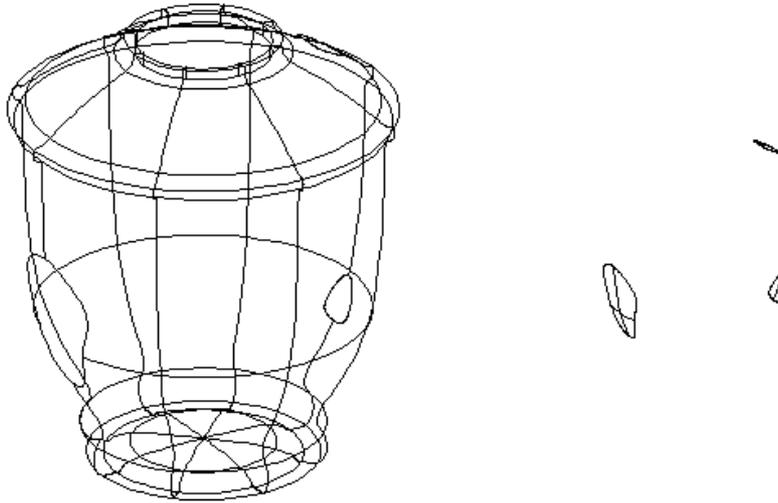
How is this achieved? In the analogy of the man walking across the field this command effectively makes the field into a lake and the lakes into islands. To make this happen DESKARTES adds another fence around the field. Try counting across the diagram above again remembering the outside rectangle is a *double fence* (*i.e.*, it counts as two).

Recall the "fences and islands" analogy if you ever need to work in detail with the trim curves, and wish to know which trim curves cut something out. Always remember that open trim curves (poly<u>lines</u>) don't cut anything out they are ignored!

Designing a free-form blend

Sometimes the blends that DESKARTES generates may not be exactly to your liking. You would like more control over the shape of the blend particularly the extents of

You now know all about trim curves.

the blends where it meets the surfaces to be blended. If this is the case you need to design a *free form blend*.

To design a free form blend:

1. Create a normal blend between two surfaces. You already have one between the spout and the body.

2. Select the blend surface `Surf/Bz/blend` and issue the command `OBJECT⇒ Delete [k]` since this blend is not quite what we want – but do **not** delete any trim curves.

3. Fit `[f]` the spout surface on the screen and pan `[x]` to put the surface in the top right corner of the screen, leaving the bottom left clear.

4. In the spout element, select the `⇒TRIM/body` curve set immediately following the handle surface and fit `[f]` it to the screen.

5. Issue the command `GET⇒ Object: Pick [g]` and point on the spout surface to the trim curve where the (deleted) blend surface met the spout.

6. The correct polygon (probably the last one in the set) should be selected in the bottom field of the object window. Issue the command `TRIM⇒ Change: Open/Close trim`. This opens the trim curve making it a polyline. This is required since this trim curve doesn't simply cut a hole in the surface - it actually cuts a portion of the surface off completely. If the trim curve cut a hole in the surface, this step would not be required.

7. Now try the command `CURVE⇒ Change: Approximate` to create a Bézier curve choosing the points option and specifying 20.

8. A new Bézier curve is created which closely matches the original polyline. Select the original polygon (now a polyline) again, the one immediately before the new Bézier curve and delete it `[k]`.

9. Select the Bézier curve in the trim set again and enter curve edit mode `[o]`. You can now move the points that control the curve in the trim curve window and watch the curve, which will define the boundary of the new

blend, move in the 3D window on the handle as well. You will probably want to use the global command **A**, which keeps the curve smooth. Edit it to taste but don't be too ambitious. One rule must be obeyed - the control points at either end of the curve must end up at the same vertical level so that they meet when they wrap around the surface - REMEMBER THIS!

Note : when editing the curve don't forget you can zoom in to see more detail and give finer control of any movements.

10. Repeat operations 3-8 for the body surface. You will not need to perform operation 6 on this curve. Don't bother to edit this curve, operation 9, though you could if you wanted.

11. Select the spout and body surfaces in turn and fit them to the screen using [f]. If nothing appears you will need to perform a TRIM⇒ Change: Invert Cut Part on the surface.

12.   To create the free form blend issue the command TRIM⇒ Blend: Free-Form. The new blend should appear.

You have learned to how to design your own blend

This is an extremely powerful command and it is possible to ask DESKARTES to do the impossible in which case the command will fail. In general keep the surfaces to be blended as simple as possible and generally speaking rounded (no sharp corners). If the command on the coffee pot fails it is probably because your spout cross-section is too complicated. Try rebuilding the handle with an oval cross-section before trying the command.

Save this file before continuing to next Lesson.

- ***To learn more on blending:***

.. Read through the TRIM section in the Reference Manual

Lesson 17 : Creating A Fitted Surface

In this Lesson, you will learn more about advanced patterning as it specifically relates to ceramic designs. As you have seen DESKARTES allows you define patterns on the surface of a model and generate extremely realistic pictures of your design. More importantly DESKARTES allows you to flatten the pattern to generate the shape and artwork for the 'transfer' needed in production. The industry term for this is a 'fit'.

We will review the procedure for applying textures and then procede on to creating the fit. For this purpose We will use a new model of a plate.

Creating a Basic Plate

We will keep the model simple for this exercise. Start DESKARTES and create a new element called plate and a new X projection set. In this projection set input and edit a curve as shown below.
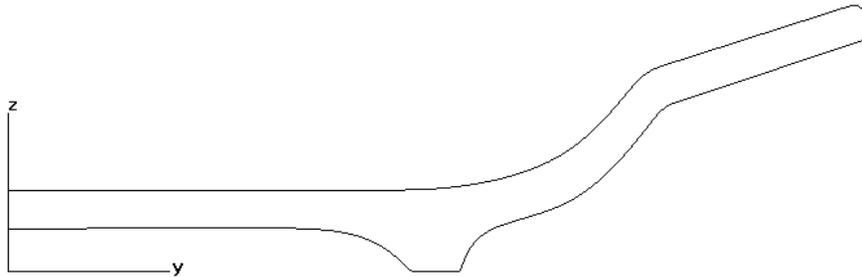
The rim of the plate, where the pattern is intended to be applied, is quite angled in this deisgn to exaggerate the fitted shape.

Now to apply a textured area to the rim. We could just apply the texture in the way desribed earlier in this turorial. Since we know that we are going to want to create fit of the shape for production we could do some preparation work now.

Separating the patterned area

The area to be flattened out to create the fit shape, where the pattern will be applied needs to be separated from the main body. This is easily achieved in DESKARTES so long as certain rules are adhered to. The command we will use is SURFACE⇒ Edit: Split in two which takes any surface and splits it in to two parts *along a parametric line*. A parametric line is a fundemental part of the definition of the surface. The best way to see where along the surface these lie is to return to the defining projection curve, edit it and click on the 'world' icon then use function K to display the so called knot points. The small sqaures drawn on your

curve indicate where the parametric line of the surface will be (the curve is actually mathematically built up of short sections joined at these knots).

You will notice these knots occur close to a control point. So if you need to add a new knot to define the position of a parametric line for splitting you just need to insert a new control point near the place you want the knot then re make the surface. Check your curve now to make sure you will be able to split the surface correctly.
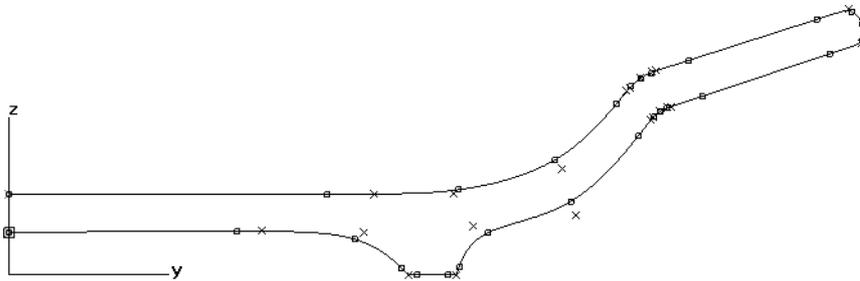
Now you are ready to splt out the area of the surface to be patterned. Here is how…

To split a surface into separate parts:

1. Select the surface to be split and view it from the x direction.

2. Issue the command SURFACE⟹ Edit: Split in two and point to the surface at the point to be split at the outside of the patterned area (point A below). The surface will be split into two separate parts creating two Surf/Bs/part surfaces in the element. The split will occur at the nearest *parametric* line to where you pointed.

3. Now use the OBJECT⟹Get command to find the top surface of the plate.

4. Issue the command SURFACE⟹ Edit: Split in two and point to the surface at the point to be split at the inside of the patterned area (point B below). The surface will be split into a further two separate parts creating

two `Surf/Bs/part` surfaces in the element (a total of three). The split will occur at the nearest *parametric* line to where you pointed.

Point A

Point B
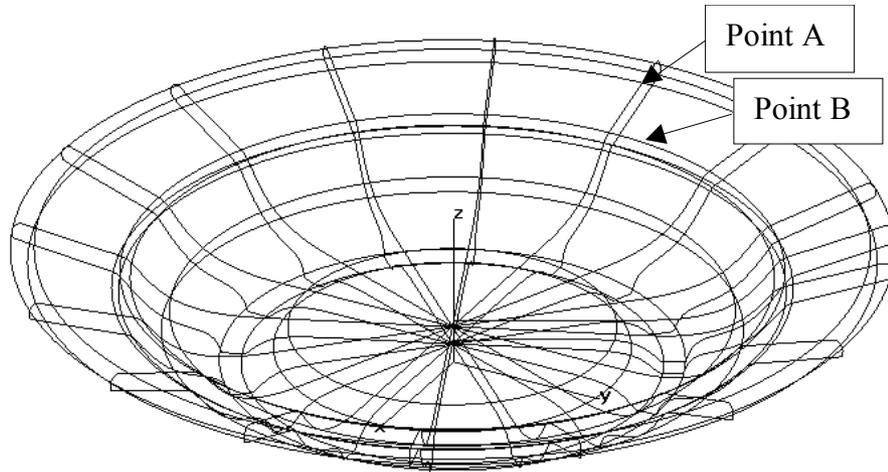
You should now have the three parts of the surface seperated into BS/Part as inllustrated in the diagram below which shows the parts moved away from each other (you should not move yours!).
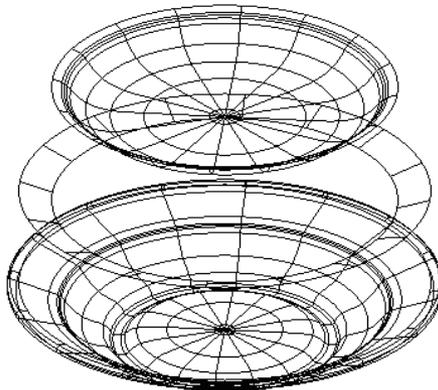
It is now time to apply the texture to the rim surface.

Texture mapping

Now to place the logo on the plate.

To define a texture:

1. Select and display `[f]` the surface for the rim of the plate.

2. Give the command `TEXTURE`⟹ `Area: Create New`.

3. Tell the system to apply `colour image` texturing.

4. In the listing that appears first click on the `DA_Textures` button then pick "DAlogo" as the `name` of the image. Use the `SHOW` button to preview the picture if you want. Click `OK`.

5. Leave the texture's `material` blank then it will assume the same material as the plate.

   In the `replication` parameters you need to produce multiple copies of the texture, so enter 24 in the `sideways` field.

   `Blurring` smoothes out the texture, so that it's individual pixels won't show so sharply. Use it if you like.

   `Adaptive mapping` minimises the distortion of the texture as it spreads on the surface. It should normally be applied, so click `YES` on it.

   Leave `transparent background` to `NO`. This way only the logo will be shown on the surface with it's own background colour.

   Finally, click `OK` to accept the chosen parameters.

5. In the next dialogue box select the parameter option `whole surface`.

Otherwise, the empty parts in the texture will show through.

A rectangle with an arrow inside appears on the surface. You may want to render a picture of the design to see the texture applied.

Flattening a surface

So having successfully split away the part of the surface to be patterned it can now be flattened by DESKARTES.

To flatten a surface:

1. Use the OBJECT⇒Get command to find the part of the surface to be flattened.

2. Issue the command TEXTURE⇒ Flatten Surface.

   You should see the flattened surface created. When viewed from Z this is the shape required for the decal. This shape of the flattened surface could now be used in DESKARTES as a template for painting. If you want to use this shape in another graphics package it is best to first issue the command TEXTURE⇒ Flatten Contour. This produces a drawing which can be written as a Data Transfer file such as DXF or Postscript.

Now continue to make a flattened decal with textures applied.

3. Slect the flattened surface, Surf/BS/flat and issue the command TEXTURE⇒ Flatten Image. This will produce a copy of the flattened surface but with the texture information applied as well.

4. View the model from Z then issue the command TEXTURE⇒ Match:Camera To Eye and enter a small number (5) into the view angle dialog box which appears.

5. Render the second flattened surface (with the texture applied) and you will see the decal of the required shape being generated. Render this at high resolution as a background process for production quality images.
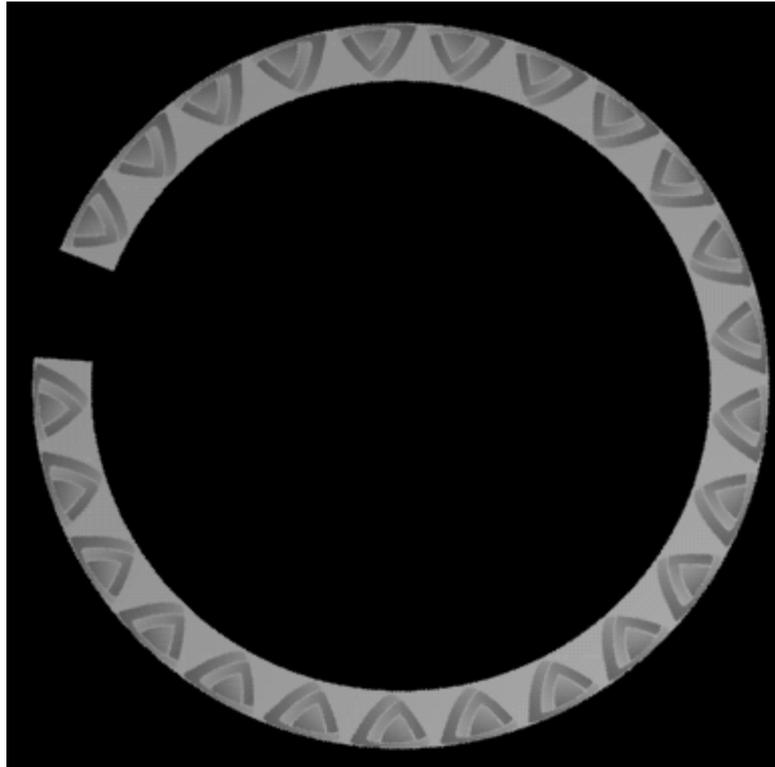
Lesson 18 : Bump Maps

This exercise investigates different ways of producing complex reliefs or engraving on a surface. These use the example of a flower that is shown below in the form of a bumpmap.
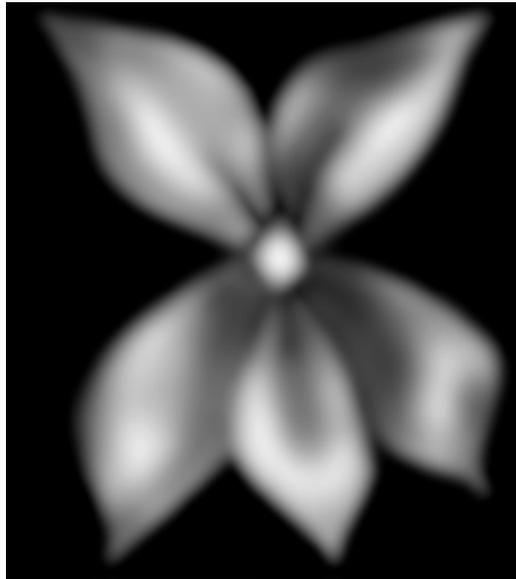
What is a bumpmap?

A bumpmap is a technique for creating the **illusion** of reliefs or engravings (raised or lowered sections) on a surface. If a picture is the only intended output from the model then bumpmaps are a valid option. Since it is an illusion only (the surfaces remain flat) DeskArtes provides a more advanced technique if you need to manufacture the 'bumps' by machining.

Bumpmap Pictures

A bumpmap is a monochrome image where variations in color from black to white relate to variations in height from the norm of the surface. As an example, if a leaf shape were to be cut into a surface the texture below would need to be created first.
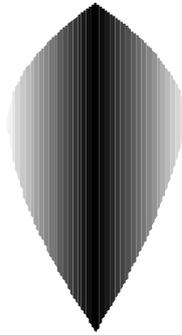
As the texture turns to black, the bump map will cause the illusion of a deeper cut being made into the surface.

Bumpmaps are normally applied as a texture. Before they can be applied the texture needs to be created using any paint package, one that supports graduated fills is ideal. An example of creating a picture suitable for a bumpmap using one of the most common paint packages, Photoshop, is given in Appendix A.

As a practical example, you could create the pattern shown at the start of the tutorial. This could be applied to the base of the Jewelry Box created in Exercise 1. Load the Jewelry box model and locate the `Base` surface.

To apply a bumpmap texture

⚫ Select the **surface** to which the texture is to be applied and view the surface from the side (X or Y).

⚫ A texture can be applied as a bumpmap to the surface using `Texture⇒Area:Create New`. Choose the option for `bumpmap` and `OK`.

⚫ Select the name of the bumpmap picture in the list.

⚫ In the dialog box, choose the options to repeat 12 times around the surface (`sideways`) using `Adaptive Mapping`. Click `OK`.

⚫ Position it using the `Around` option. Click on the surface at the bottom and the top of the band where the flowers are required. If this option is not given to you then you have made the mistake of selecting the element name (top pane) and not the surface (middle pane). Undo the last operation and try again.

- To see the result of this it will be necessary to generate an ExTrace picture.

Bumpmap Surfaces

If the model is to be machined with the 'bumps' on, a more advanced technique must be used. Instead of applying the texture directly to the surface, the grayscale picture is used to create a 'surface' that can be wrapped onto the base surface. The 'surface' is made from small triangles called facets. This technique is can be very resource intensive if the model is large or very detailed. Expect DeskArtes to operate more slowly when using facetted models.

To apply such a model on the jewelry box it is first necessary to delete (using OBJECT⇒Remove) the ->Texture you just applied. It would also be a good idea to create a new object called flower for the bumpmap model. Now open the File Manger window and locate the texture.

Click on the file with the middle mouse button and choose the option for 3D BumpMap. You will be asked to enter a number to determine the number of points to be used for the model. The higher the number the better the definition, but the more data is used and the longer all operations on the model will take.

After a few seconds, if you look carefully you will notice a new file appear called cobj_filename. This contains the model of the bumpmap. Double click on this file to load it into your jewel box model.
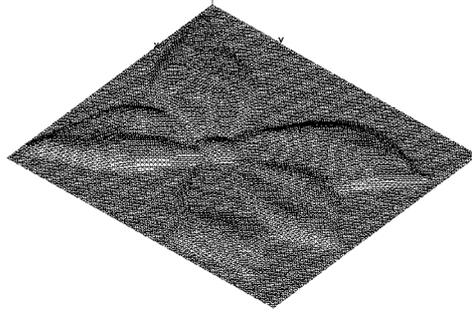
The size of the bumpmap you have just created can be set by using the command TRANSF⇒Fit:Size. This command asks you to enter the size you require the surface to be scaled too. Set this to a min 0mm and max of 10mm in X and Y and min of 0mm and max of 1mm in Z.

Rotate the flower 90° about X, then translate it to the position shown below, outside the base. Make sure that when viewed from the side (X) and front (Y) that the flower is positioned at the correct height to project onto the side of the base as shown on the right below.
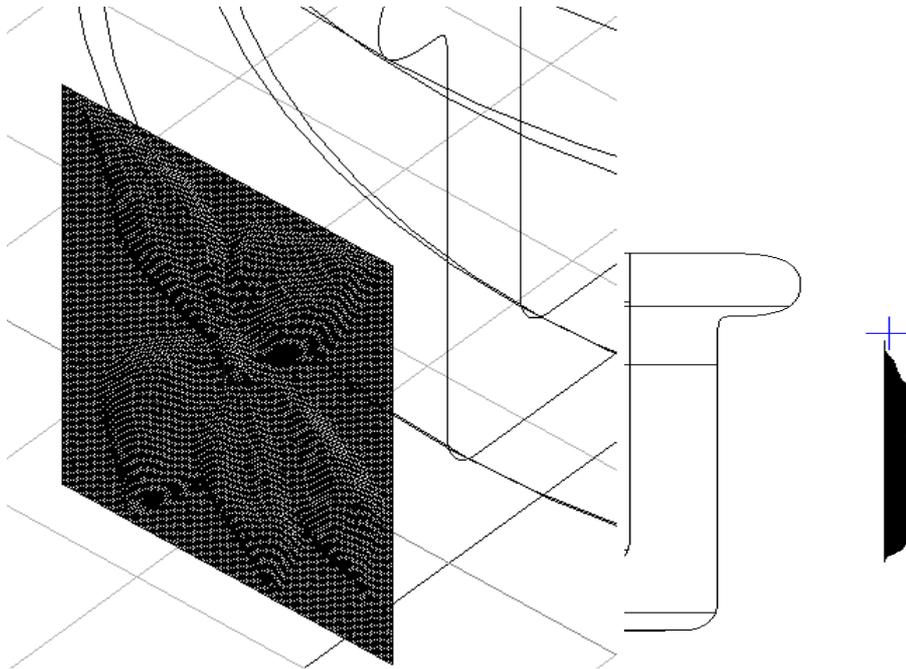
The right hand picture above also shows the location of the fixed point for the flower surface (the cross). Set it to this position using the left-hand mouse button option now. Notice the point is just to the right of the flat base of the flower.

Use the SURFACE⇒Deform:Project To Surface command now and pick the base surface as the receiving surface. Select the projection direction as Y and the flower will, after a short time, be wrapped onto the base.

It was important that the fixed point was set as described above, as it is this point that determines the level of the flower that is wrapped onto the base. The large flat area of the flower actually ends up inside the base. Copy and rotate the flower a total of 12 times around the base (30° intervals).
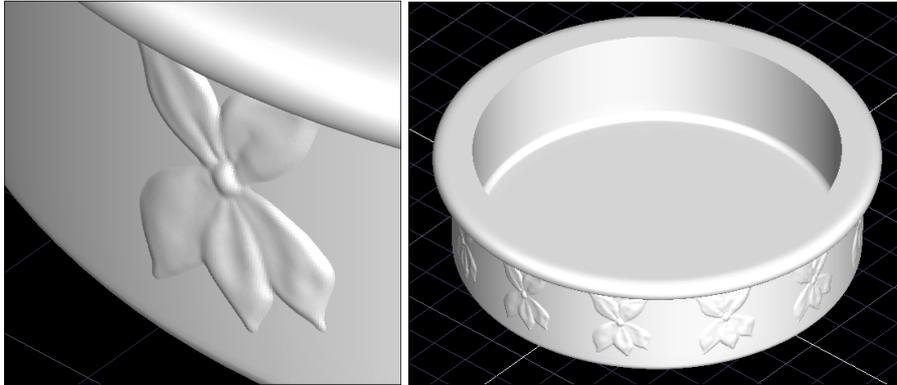
Render a picture to see the results.

Issues covered in this exercise

- *Bumpmaps applied as textures are good for making pictures.*

- *Bummaps converted to facetted surfaces are good for making physical models.*

- *Working with high-resolution facetted models can place a strain on the resources of your computer - be patient.*

Lesson 19 : Creating Grayscale Images

This section covers the creation of grayscale images suitable for the generation of bumpmaps. Any advanced painting package is suitable for this. Perhaps the most widely used package of this type is Adobe Photoshop and it is the use of this software that is described here.
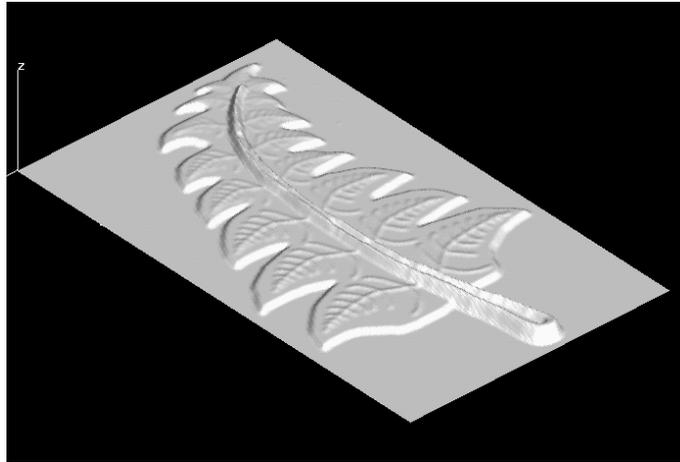
Image Sources

Designers have long known that the inspiration for designs can come from many sources such as nature and design work in other areas. Using traditional techniques, these sources could provide little more than inspiration. The advent of photocopiers meant that design ideas could be reused in a more direct way. Computers employing digital techniques and scanners have enabled the reuse of design ideas to be taken even further.

Ultimately the success of any design depends on the talent of the designer and the ability of the designer to use the tools provided. Unfortunately, this tutorial cannot help with the first of these but it can help to explain how to use the tools found in Photoshop.

Photoshop can be used to create designs from 'scratch'. Even in this case certain aspects of the software make it much better than using paint and canvas. In particular the cut and paste commands allow for easy repetition of design elements much the same as we have already seen in the 3D case with DeskArtes.

As an alternative to drawing from 'scratch', a scanner can be used to scan in original artwork to be used 'as is' or as an underlay to aid with freehand drawing. Even physical objects such as cloth can be scanned and used to add a natural feeling to the computer artwork. This tutorial concentrates on creating artwork from 'scratch'.

Artwork Creation

We are going to use the natural world, in particular a fern, as the inspiration for the design. This is interesting as it allows us to use repetition of design elements for each of the leaves of the fern.

Photoshop version 4.0 is used in the creation of this tutorial. For any such artwork, it is **highly** recommended that a pressure sensitive pen and tablet be used as the input device. Those of us that do not have such a device have to make do with a mouse.

To start with, create a new image by using FILE⇒New. Enter a name and type in an image size of 1000 by 2000 pixels. Importantly the mode should be chosen as grayscale. The background can be set to white. The number of pixels chosen may seem high but this allows a better definition for the drawing. The grayscale option was chosen as bumpmaps used the varying intensities of black and white to represent different heights in the model.

As a starting point for our fern design, draw the main stalk. An important feature of Photoshop is the ability to use layers to segregate different elements of a design. Create a new layer now using LAYER⇒New⇒Layer for the stalk Choose black as the color. A good tool for color selection in grayscale images is found in the color window (Use WINDOW⇒Show/Hide Color to see this window).
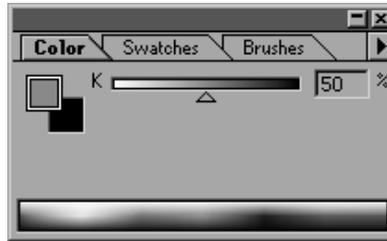
This contains a slider that allows the shade of gray to be selected. Remember the shade of gray directly relates in the height of the final model with white as one extreme and black as the other extreme. Choosing black (100%) for the fern stalk makes it the highest (or lowest) point in the model.

There are several drawing tools in Photoshop. Using a tool that has a sharp transition from on color to another causes a sharp step in height in the final model. Natural objects, such as ferns, do not have step transitions so it is better to choose the brush or spray.
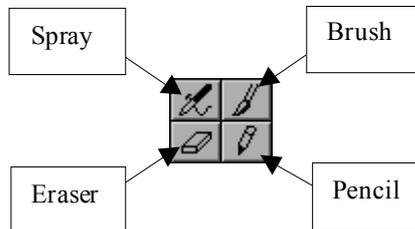
For this example choose the brush and in the color dialog window choose the Brushes panel. This shows different brush effects, choosing from the top row gives a hard edged brush which will give the same effect as the pencil so choose one from the center or lower row.
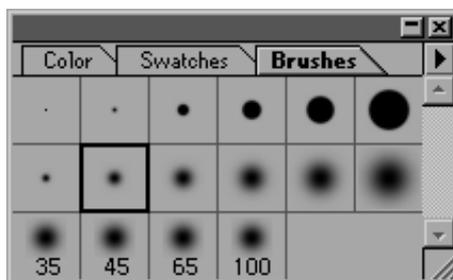
Draw the stalk as shown below – use a thinner brush for the narrow end of the stalk.

From the color window, choose 70% gray and add the central line of the stalk.

Create a new layer now using LAYER⇒New⇒Layer for the first leaf. Choose 70% gray for the color and a medium brush. Draw the spines of the leaf.

Of course, you could repeat the exercise, drawing each leaf in turn, but why not take advantage of the digital editing tools provided. Choose the command LAYER⇒Duplicate Layer.... The picture will look no different, but if you look at the list of layers you will see a new layer has been created which contains a duplicated leaf exactly on top of the original.

Now choose the move tool and drag the leaf to a new position. The duplicated leaf needs to be slightly smaller. This can be achieved using the LAYER⇒Free Transform command. After executing this command, an editing frame will be drawn around the graphics with a small box in each corner. These boxes are the editing handles that can be dragged to scale the image. Dragging near the box allows rotation of the image. The cursor changes shape to indicate the different scaling or rotation functions.
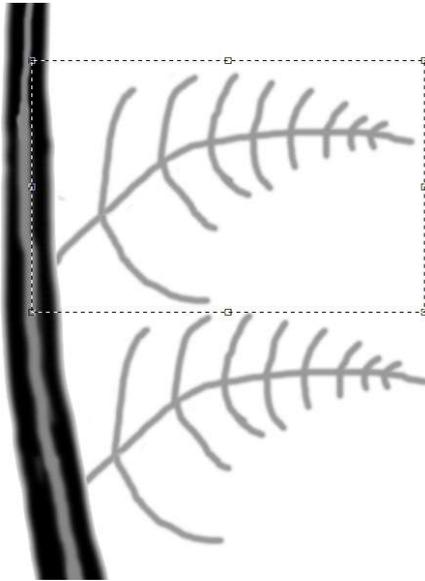
Scale and rotate the duplicated leaf to a suitable position. To finish editing, double-click inside the editing frame. Repeat this process adding leaves all around the stalk.
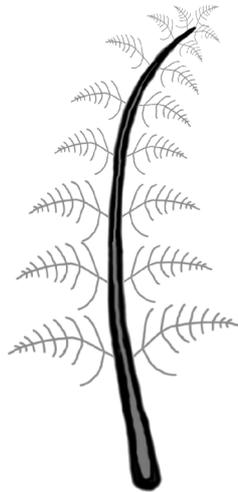
Now to complete the picture, create another layer and choose a color of 40% gray. Draw a leaf border around the stalks. Make sure this border forms a complete loop with no gaps in the boundary. Fill this area using the fill tool as shown below. This will probably appear to overwrite all the other graphics so choose LAYER⇒Arrange:Send To Back to put this layer behind all the other layers. Save the image as a Photoshop file before continuing.
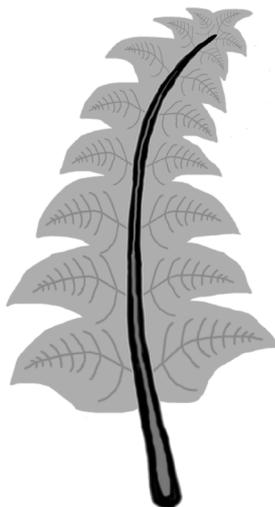
The next step is to remove all layers from the picture. This is called flattening and the command is LAYER⇒Flatten Image. To finish the process it is recommended that the image be blurred. This has the effect of smoothing out the boundaries between shades of gray giving a more natural effect. Blurring can be achieved using the command FILTER⇒Blur…Gausian Blur. Vary the Radius number to achieve a suitable amount of blurring.

Note that the blurring effect is applied to the current layer. Since we have already flattened the picture, there is only one layer so everything will be blurred. If you only wanted to blur parts of the picture or you wanted to blur different parts by different amounts then you could perform the blur operation before flattening.

Save the image as a TIF file and convert it to a bumpmap surface as described on page 210. Remember the DESKARTES command TRANSF⇒Fit:Size can be used to ensure the correct size and depth proportions. Also The command TRANSF⇒Object:Mirror is useful if the final object is inverted in any direction.
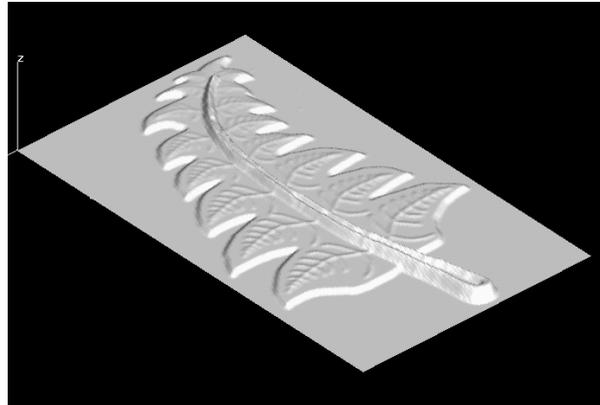
Lesson 20 : Advanced Building Methods

Once again, you will work on the coffee pot model. You should now have running with the `geom_coffee` file loaded. The techniques so far used for shape creation have all used the idea of generating 3D surfaces from a combination of 2D curves. This has enabled relatively simple interaction from the user to generate complex shapes. It is possible however that the most complex shapes are more easily created by generating surfaces directly from 3D curve - a new concept for DESKARTES users! Although it is possible to draw 3D curves directly in DESKARTES for ceramic applications, it is more common to use trim curves as the starting point for your 3D curves. Read on to find out how!

3D Building using trim curves

It is possible to use the curves generated by trim and blend operations as the projections for the 3D building of surfaces. If you remember in the previous Lesson we talked about trim curves and explained that they were stored as 2D polygons in the parameter plane of the surface. The trim curves need to be modified before they can be used for 3D building. Here is an example of the steps involved. We will use the idea of building a small horseshoe shaped design feature on the bottle as the scenario for this exercise.

Creating a design feature

To start to build a 3D design feature from trim curves we need some trim curves. So let's make some. Remember though that this is just one way of creating trim curves. Any trim curves can be used for this technique:

Making the trim curves

1. View the `body` surface of the coffee pot from the x direction.

2. Make a new element called `feature` and an x projection set.

3. Input **two** curves to describe the top and bottom of the smile. Perhaps use the curve offset command to create the second one - it's up to you! Edit the curves making sure that both ends of the two curves meet exactly.
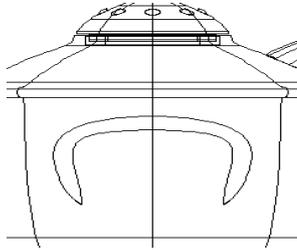
4. Use these curves to create two extruded surfaces, to pass through the body.
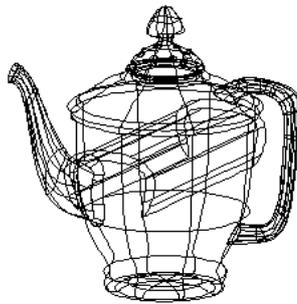
5. Intersect the first extruded surface with the body.

6. Intersect the second extruded surface with the body.

You should now have the trim curves, four in total, we need for building the surface. Two of these trim curves are on the front of the body, two on the rear. The next

stage is to make these trim curves into true 3D curves. Since the front and rear features are identical, we only need to work on the front at this stage.

Convert trim curves to 3D

1. Select as the target object the top most trim curve on the side of the body nearest to you. OBJECT⇒ Get [g] may be useful here. Change its colour to be sure you have the correct curve.

2. Select the command TRIM⇒ Change: Trim to 3D . A new curve set is created called Curves/3D.

3. Repeat 1&2 for the lower trim on the front of the body.

The two new curve sets called Curves/3D now contain the required geometry. The other objects in the feature element can now be deleted.

Delete redundant geometry

1. Select each object in feature in turn and delete it **except** the two objects called Curves/3D.

The next stage is to turn the true 3D curves into curves suitable for 3D building. They need to be two 3D Bézier curves in a Projections/3D object.

Create 3D projection curves

1. Create a new 3D projection set.

2. Select the polyline in the first curve set called Curves/3D.

3. Using CURVE⇒ Change: Approximate turn this curve into a Bézier curve via the number of points option. Use a value of 20 for the number of points.

4. Move this new curve to the Projections/3D set. Select the Bézier curve. Issue the OBJECT⇒ Cut/Paste command. Select the Projections/3D set. Issue the OBJECT⇒ Cut/Paste command again.

5. Repeat steps 2 to 4 for the second curve set called `Curves/3D`.

6. Delete the two curve sets called `Curves/3D`.

You should end up with a single 3Dprojection set containing two Bézier curves. We now have two Bézier curves for building.

Building the surface

1. Create a section set and input a curve.
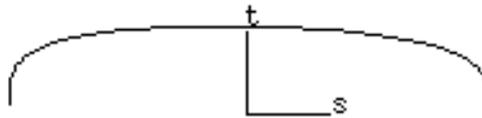
2. Build the surface `[b]`. If the surface that is built is inverted (it sticks into the coffee pot rather than out of it) you will need to `CURVE`⇒ `Direction: Change` on the section curve.
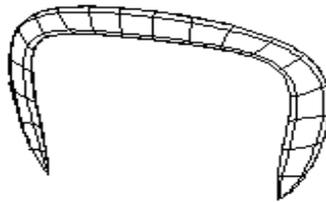
3. Select the **surface** (not element) you have just created. `OBJECT`⇒ `Copy [j]` and `TRANSFORM`⇒ `Object: Mirror [m]` in the x direction about the centre of the body to form the feature on the back of the body.

The only thing that remains is to sort out the body surface. You may have noticed that when we trimmed the surfaces to make the 3D trim curves nothing was cut out of body. Do you know why? Since the two surfaces were trimmed separately the

result was two open polylines - polylines have no effect on trimming remember! So to cut a hole in the body we need to join the trim polylines to trim polygons.

Closing the polylines

1. Click on the trim set immediately below the surface in body.

2. Issue the command Curve⇒ Combine: Join All. The polylines are changed to polygons and two holes are cut in the body. (if any polylines remain select them and issue the command TRIM⇒ Change: Open/Close trim.)
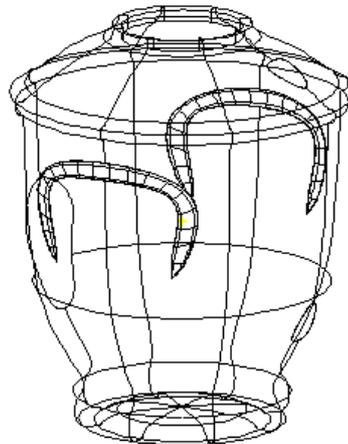
You've seen how to use trim curves to build in 3D!

Lesson 21 : Turning the Screw!

In this final Lesson, you will work on the bottle, creating a model of its contents, calculating the content's volume and adding a helical screw thread to the model.

Read in the file `geom_bottle`.

Calculate the volume

One of the design parameters for a bottle like this is the *volume* it holds. DESKARTES can calculate this for you. Before we can get an accurate answer we need to decide how full the bottle will be with liquid - where will the waterline be?

To define the water line:

1. Select the `bottle` element as the target object.

2. Create a surface primitive `SURFACE⇒ Design: Primitive`. Choose the `plane/box` option and enter the following values into the dialogue box -

   xmin = -100, ymin = -100, zmin = 0
   xmax = 100, ymax = 100, zmax = 0

Use the tab key to move from one parameter field to another!

3. Unless you made a typing error, a planar surface is created at Z=0. Move the plane in Z direction until it is at the correct height for the waterline - you decide.
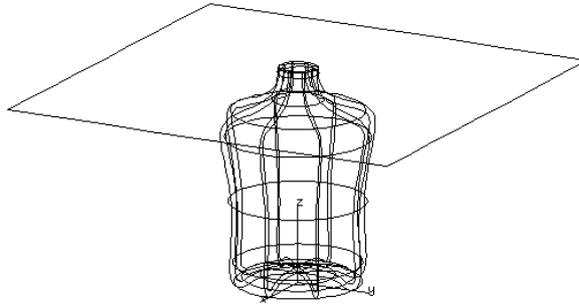
4. TRIM⇒ Intersect: Surface the planar surface with the bottle to chop of the top of the bottle.
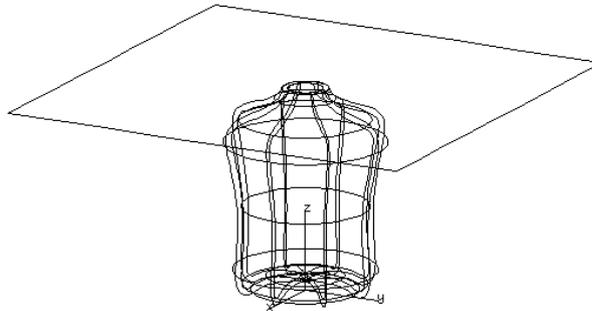
5. Remove the trim curves on the outer side of the bottle, as follows:

    Display the plane surface alone [f]. Select the *trim set* of the plane surface. Pick [g] the outer trim curve by pointing at it *on the surface*. Delete [k] the trim curve. Select and display [f] the surface again. TRIM⇒ Change: Invert Cut Part if the wrong part of the surface remains.

6. Repeat step 5 for the bottle surface picking and deleting the trim curve around the outside surface of the bottle.

You should be left with the two surfaces which together form the outer surfaces of the fluid. In the below diagram, the top part (plane) has been lifted a bit to show it clearer (but don't *you* lift it!).
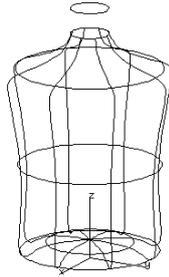
To compute the volume, the surfaces must share a consistent ***normal direction***, and be faceted into a ***polyhedron***.

To calculate the volume:

1. Select the bottle element, and copy it to a new element called `volume`.

2. Give command SURFACE⇒ `Direction: Change`.

3. DESKARTES displays the normals for both surfaces in turn, and asks if the direction should be changed. Change the normals to point to the outside of the model, as in the image below.
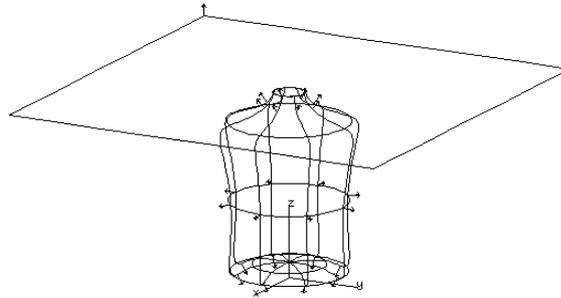
4. Perform SURFACE⇒ Change: Polyhedron. Accept the default
   tolerance. This changes the surfaces to faceted ones, a polyhedron.

The tighter the
tolerance, the
more accurate
the volume!
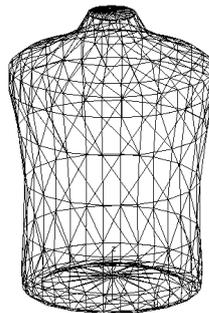
5. Finally calculate the volume enclosed by the polyhedron with
   DIMENSION⇒ Polyhedron: Volume.

The volume is reported in the message line in ***cubic units***. If you interpret the units
as millimetres, the volume 240.000 cubic units would correspond to 240.000 cubic
millimetres, *i.e.*, 24 centilitres.

Notice that for the volume to have a real meaning the polyhedron must enclose a
single volume, it must not have any holes or gaps. That's why we added the plane as
the waterline – to exactly define the single volume to measure.

Add a screw thread

To finish the bottle let's add a screw thread to the top. Before you start, read in the original `geom_bottle` model again. Make the cap passive [a] as you don't need to see it now.

A simple screw thread can be formed by tracing a circular section curve along a helical path - sounds like a `Build` operation. We'll use a ***3D projection curve*** again. This time DESKARTES provides a command to create it automatically.

To create a thread:

1. Create a new element called `thread`.

2. Create a `3D` projection set.

3. Create a helix with CURVE⇒ `Design: Spiral`. Answer the questions with 4 loops, height 1.5 and width 20.0.
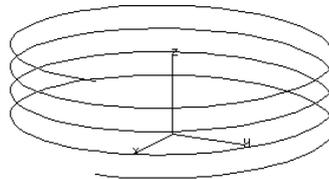
4. Move and scale the helix until it fits around the neck of the bottle.
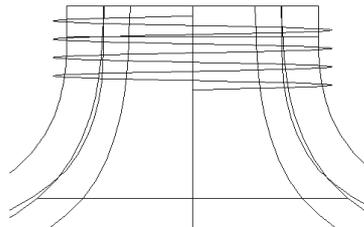
5. Create a section set containing a circle of radius 0.5.

6. Build [b] the surface, accepting the default orientation parameter choice.
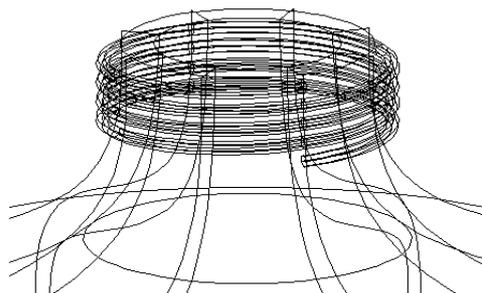
The thread surface should now fit snugly around the bottle. However, you may be unhappy with the end of the thread since it finishes abruptly - it should disappear into the bottle surface. This can be achieved by carefully editing both ends of the spiral curve, moving them in a little towards the centre of the bottle and re-building the surface. Enter into the 3D edit mode using [o], and work it out!

Build the thread again, and trim to the bottle.

To display the surfaces, finally try a new rendering option:

To draw a hidden-line image:

1. Display on screen what you want to render.

2. Give command PREVIEW⇒ Preferences.

   Set the hidden lines option to silhouette, and accuracy to accurate. Click OK.

3. Give command PREVIEW⇒ Hidden Lines.

Wait a while, and your model is displayed, hidden lines removed.
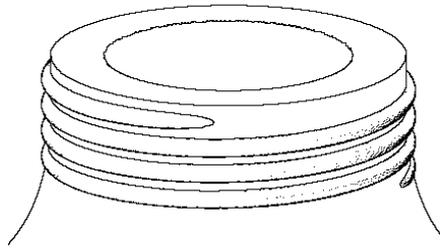
You made it!

Congratulations! You've come a long way and reached the End of the DESKARTES Tutorial.

You've seen applications of most of the DESKARTES commands. Many of the commands can be used in various ways for different modelling and visualisation tasks, as you'll quickly learn when designing on your own. Remember – the only way to *really* learn DESKARTES is by *using* it!

- ***Before you close this Book:***

... Have a glance through all the menus and buttons

... Review the commands you've used

... See if there are commands you haven't seen yet

... look up the Reference Manual for further explanations

...Some additional exercise are included in the Appendix

Appendix : Modelling Exercises

The following exercises all feature items commonly found on the dinner table. This is a good source of models for exhibiting many of the features of DESKARTES and clearing up some common user misconceptions.

Illustrations are provided to help clarify the computer based design process by describing the creation of models specifically chosen to illustrate important techniques. Since the dinner table is an everyday artefact you may like to look closely at the designs you are familiar with in your personal surroundings to find examples of the items shown and model these as well. The first time you work through the exercise it is recommended that you stick to the shapes shown.

Exercise 1 : A Vase
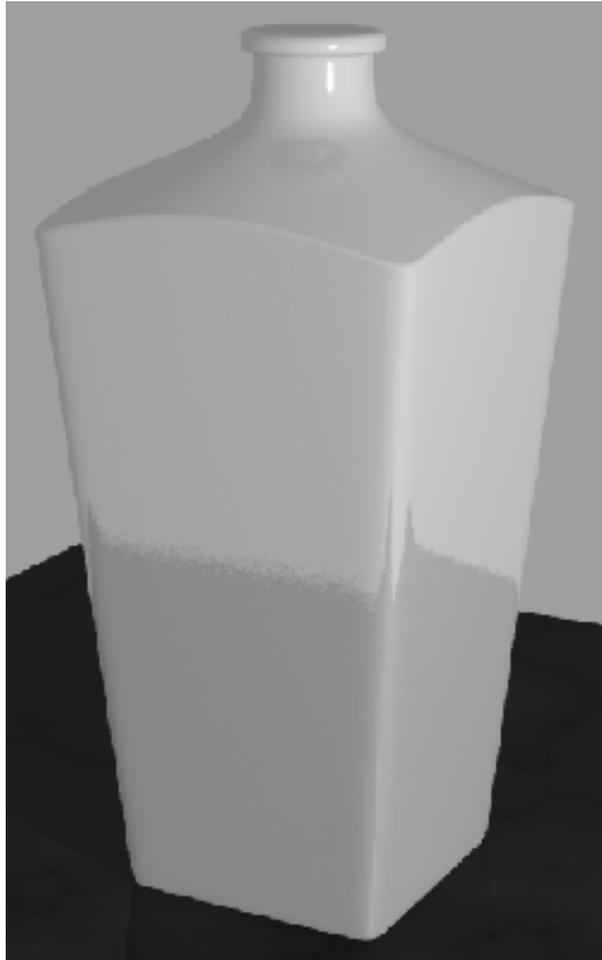
The picture above shows a nice simple vase - nothing to difficult about that is there? A gentle introduction to this Project Book series. So take a few moments before reading on to decide how you would model such a simple object in DESKARTES.

Single Surface Building?

Most new users of DESKARTES would fall into the trap of recognising this model as a candidate for the BUILD⇒ Create: Surface [b] since the vase clearly changes cross-section from square to circular. So you might think you need to draw the side profile as two Xprojection curves and assign the cross-sections as shown in the diagram below.
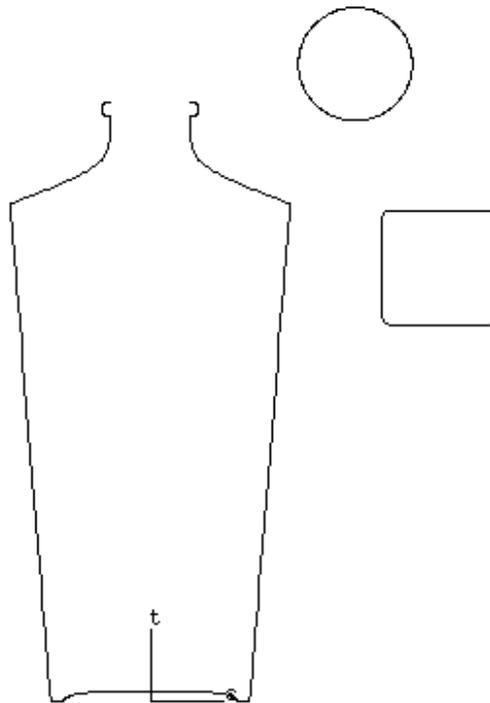
Can you see why this would not produce the correct result? If you can't try modelling it now.
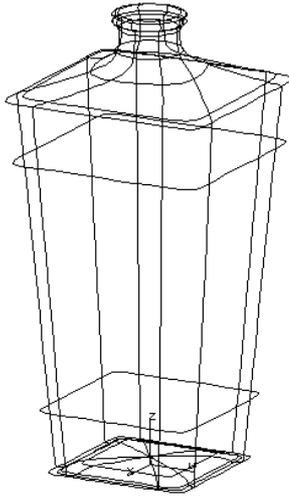
If modelled this way the vase would indeed change from square to circular but the way in which the change occurs would not be anything like the intended vase. So another approach is needed. The 'sharp' edge and the arch shape at the top of the square sides would immediately indicate to an experienced DESKARTES modeller that the vase needs to be made out of a number of surfaces!

Multiple Surface Building

Here is a better way. First of all model the square part of the vase as a separate surface. There is no **need** to use the BUILD⇒ Create: Surface [b] command (an experienced user may choose to build the surface simply because it is easy to rebuild quickly using the [b] key). Draw the curves below as an Xprojection and Cross-section in an element called Bottom. Create the using the SURFACE⇒ Design: Rotate command.
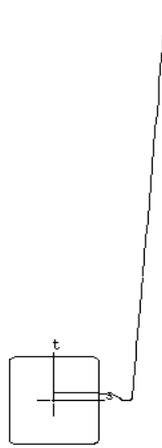
Now for the top part of the vase. Draw the second curve below as an Xprojection and Cross-section in a second element called `Top`. Draw the projection in the correct relative position to the original projection.
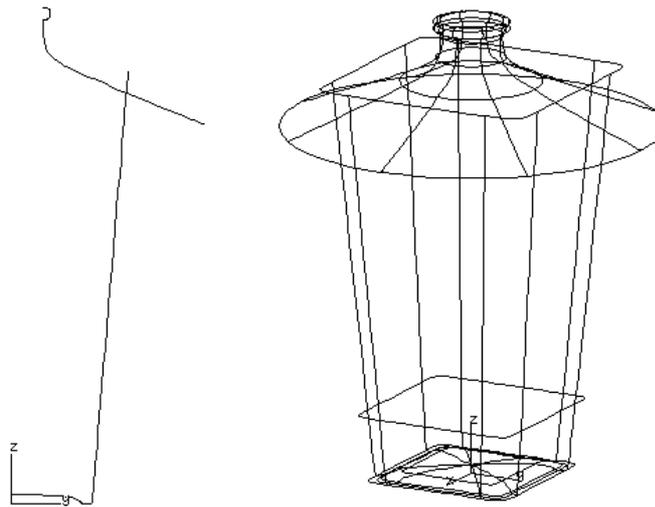
Now use the `Trim⇒ Intersect: Surface` command to trim the `Top` surface with the `Bottom`. Alternatively to be more realistic `Trim⇒ Blend:`

`Rolling Ball` the two surfaces using a small 1mm blend. This will be more like a real ceramic object.
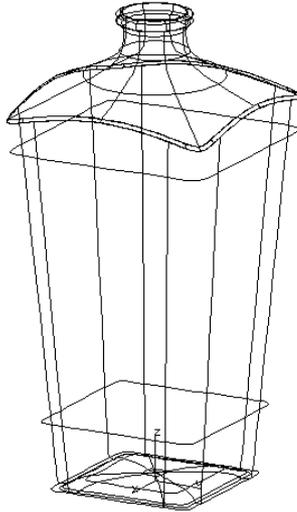
Internal Surfaces

So that's the completed model. Well not quite. The inside of the vase has not been modelled. With the inside of any model it is always good to ask yourself why do I need to model it? There can be several reasons.

- I need to calculate the volume contained by the model or the amount of material in the model.

- I need to design and manufacture an accurate assembly model to ensure everything fits together.

- The inside will be visible when I create the renderings.

If none of these reasons is true then do you need to model the inside? Would you be better using the time saved to refine the design or produce more design alternatives?

For the vase simply adapt the Xprojection curves in the two elements already created to reflect the inside shape as shown below. Do this now using the `Curve`⇒ `Design: Offset` command followed by `Curve`⇒ `Combine: Join`

`Two` to join the outer and inner curves together with a short straight line. You will need to tidy up the areas around the bottom corner and the top edge of the vase. The two curves should end up looking like the picture below.
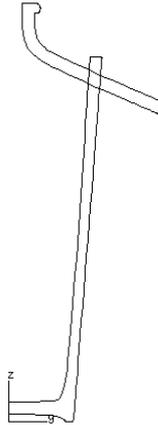
Now create the two surfaces as before and trim or blend them. Note the following though.

- If you chose to blend them you will need to be careful which of the **four** intersections you chose to blend. You need to create two blend surfaces (where the outer surfaces meet and where the inner surfaces meet) and the directions of the surface normals at each of these blends will be **different**.

- If you choose to trim the surfaces you will find that **four** intersection curves are created of course. Two of these trim curves are not required and need to be deleted.

This is not the only way of producing the inside though. The inside can be considered as separate surfaces entirely. This does have other more general advantages even in cases where the outside can be generated in a single surface and so intersection problems do not arise. The major advantage is that if the inside of this object is not visible in any picture (for example if this model had a lid on it) then when generating a rendered picture the inside would not be seen. Since it will never be seen there is no need for drawing operations including `ExTrace` to bother considering it. It can be made inactive and left out from any surfaces submitted (inserted) to `ExTrace` and the picture will be generated more quickly.

Using this two surface technique for this model the inside will have to be generated as two separate surfaces just like the outside. Create two new elements by **copying** (Object⇒Copy [j]) the original elements. Call the copies Top_Inner and Bottom_Inner. In each of the copied elements create offsets of the projection curves, tidy them up as necessary and then delete the original projection curves. The picture below shows the completed new inner curves.
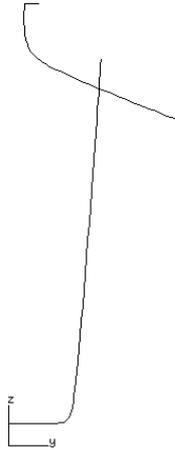
Now create the surfaces and intersect or blend the Top_Inner and Bottom_Inner surfaces separately just like you did the outer surfaces.

Issues covered by this exercise

- *even some simple models need multiple surfaces*

- *trimming and blending are essential skills of DESKARTES modellers*

- *do you need to model internal surfaces?*
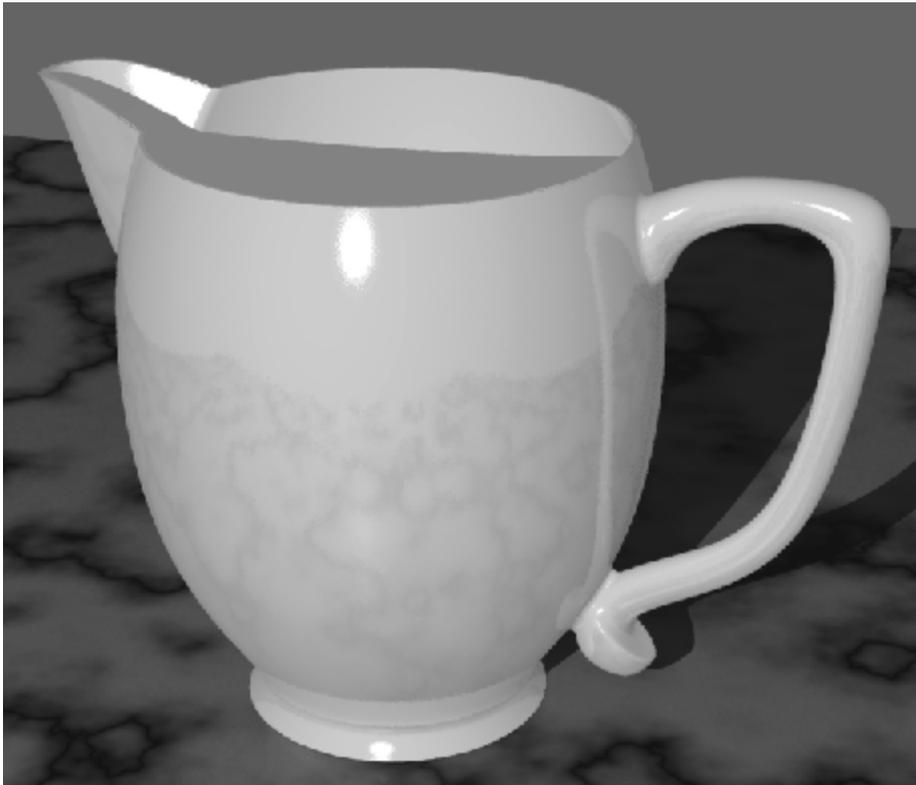
The picture above shows a jugs. The previous exercises should have alerted you to the fact that for the body and spout of this jug shape multiple surfaces are required in a DESKARTES model. This is because of the pouring spout which exhibits a sharp connection to the main jug. So take a few moments before reading on to decide how you would model this jug in DESKARTES.

Trimming Accuracy

Having recognised that multiple surfaces are required, lets take a look at what surfaces are needed to model the main body of the jug. For simplicity and to illustrate the point of this exercise more clearly we will only model the outer surface at this stage. The Body surface itself is easy to create. Simply draw the Xprojection below and design a Rotated surface.
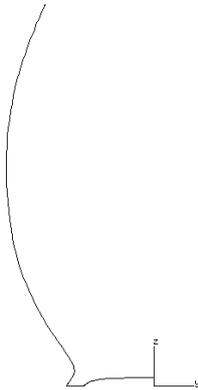
Now for the pouring spout using the build technique. Draw the two Xprojection curves, correctly positioned, and the 'U' shaped cross section then build the surface. Note that the front projection curve passes inside the jug.
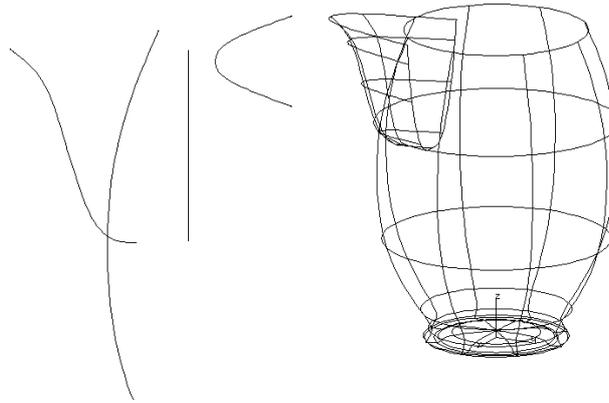
Now once again it's time to join the two surfaces together. Try it now using the
Trim⇒Intersect: Surface command as you have done many times before.

So what happened? There are two possible results.

- If the spout surface was created just slightly above the jug body the Body is fine
  but nothing has been cut off the Spout at all. If you look at the trim curves
  below the Spout surface you will see one of them is a polyline! Polylines are
  ingnored in trim curves remember.
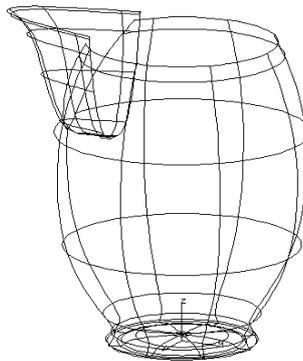
- The second possibility is that the Spout was created slightly lower than the top
  rim of the jug. In this case the spout will be correct and the body will not be cut.
  Once again the trim curves below the body surface contain a polyline.
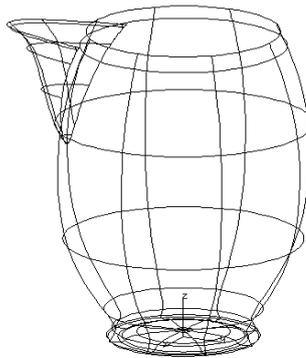
In either case the result was caused by the tops of surfaces not being aligned. Easy solution - just align them.The trouble with DESKARTES is that even small misalignments of say 0.000001mm can be detected. So it is extremely difficult to achieve this. Perhaps a little lateral thinking is required.

Cutter Surfaces

Here is one solution. Edit the projection curves to ensure the `Body` surface definitely extends well above the spout. Recreate both the `Body` and `Spout` surfaces. Ensure that the `force closed intersections` option is set to `Yes` in `Trim`⇒ `Preferences`. Now trim the surfaces as before. The spout will be trimmed correctly and the body will have a hole cut in it for the spout. Setting this preference has forced the polyline created on the body by trimming to be closed to a polygon acorss the top of the spout.
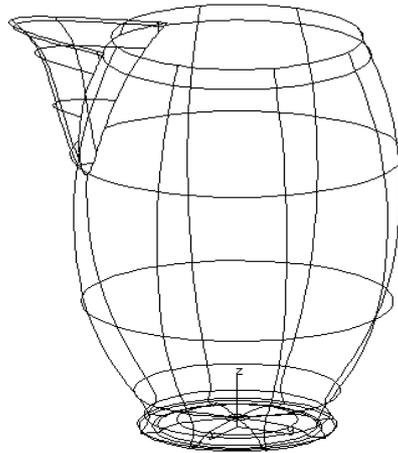
Now for the lateral thinking. The jug is taller than it should be, so we need to chop the top off it. To do this we will introduce a third, cutter surface in an element called `Cutter`. Draw an Xprojection curve for the top of the jug.
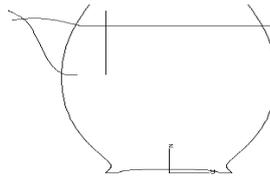
`Surface ⇒ Design: Extrude` a surface from this curve right across the jug.
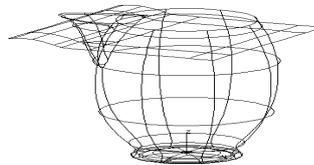
Fit `[y]` all the surfaces on the screen and select the extruded **surface**. Trim it to the other surfaces using the `Trim⇒ Intersect: Multiple` option. The body and spout surfaces will be cut back to the correct level. Make the `Cutter` element inactive `[a]` and fit `[y]` the other surfaces to show the finished jug.
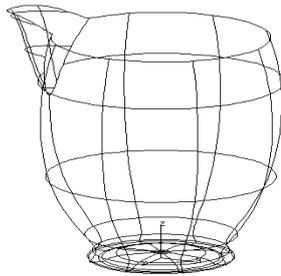
The inner surfaces of the jug pose the same problems as already discussed in the previous exercise. The choice of the best solution for the jug is left to the reader. Just remember that if the inner surfaces are created separately they will also need to be trimmed by the cutter and the `Cutter` will now need to remain active since this surface fills in the gap at the top between the outer and the inner surface.

Closed Surfaces

The handle is also interesting on this jug. The way in which the bottom of the handle meets the body of the jug is quite common and is very easily achieved in DESKARTES using the build command. Also note that the bottom end of this handle forms a closed surface. Create a `Handle` element now with an Xprojection set. Draw the handle curve below passing inside the jug at both ends.
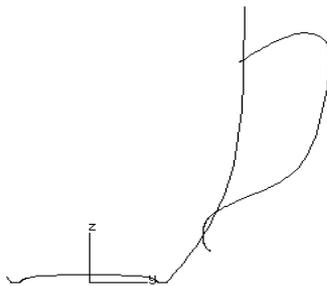
Offset this original curve and edit it at the bottom to give the correct the shape. Whilst doing this certain rules must be observed.

- The ends of the two curves at the bottom must meet exactly. This is easily achieved by editing the two curves together and using the level function [l] twice to align the end points both horizontally **and** vertically.

- If a sharp edge or point is not required at the end of the handle then the points either side of the ends of the curve (highlighted below) need to be aligned to form a straight line using the [p] command in curve editing.
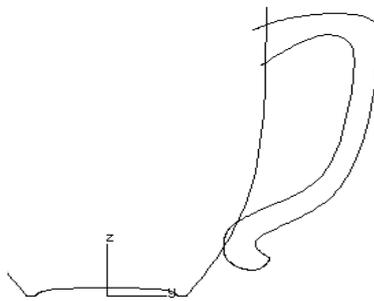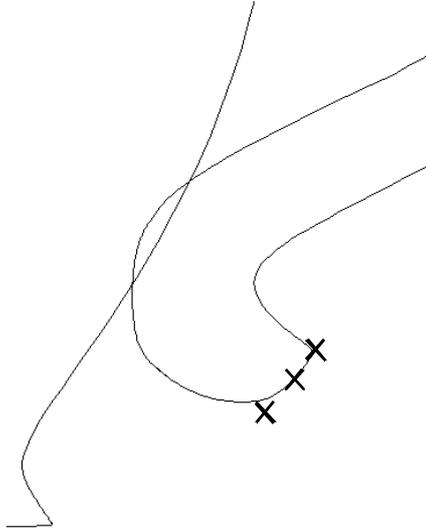
The handle also needs an elliptical Cross-section so draw that too and build the surface. Trim or blend the `Handle` to the `Body` surface in the normal way.
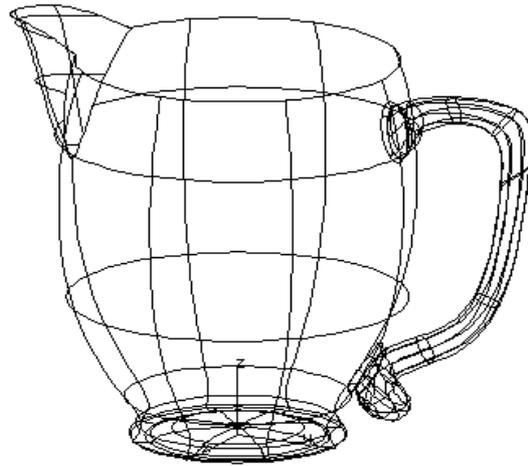
Issues covered by this exercise

•   *trims need to be closed to work correctly*

•   *surfaces which do not form part of the model can be used as cutters*

•   *points defining closed surfaces must be carefully positioned*

Exercise 3 : Lead Crystal Glass
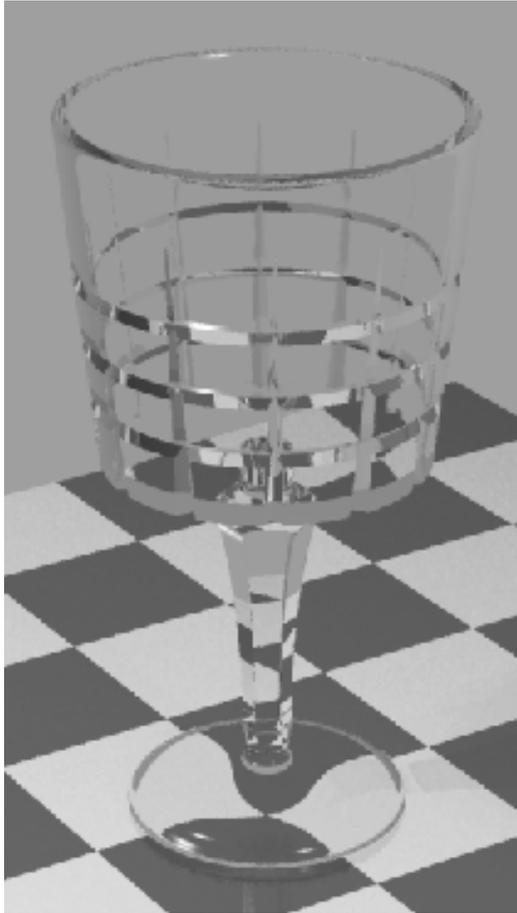
Glass objects make very good subjects for computer generated pictures. A good computer material for glass can be very impressive and the material in DeskArtes is one of the best. The example above was chosen because it will allow you to see what you have learnt in the previous exercises. So stop and think how you are going to use the experiences of earlier lessons to make the cut glass model.

More Cutters

You may have noticed the same shape on the stem of the glass as on the original vase modelled in exercise one. The arch shape should indicate a cutter surface is needed and you should have recognised that a second cutter is needed to create the vertical cuts in the side of the glass. The horizontal 'cuts' around the glass can be made as part of the main surface. As a starting point for the model draw the curve below as an Xprojection in an element called `Glass` and rotate the surface.
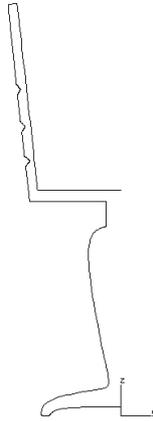
Create an element called `Stem_cutter` with the Xprojection curve shown below.
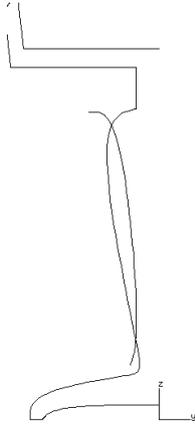
This cutter will form the shape of lower stem which needs to be rotated with a hexagonal in cross-section. To complete the stem TRIM⇒ Intersect: Surface the surfaces in Stem_cutter and Glass.

Repeating Curves

The second cutter element called Glass_cutter should be drawn to contain the Xprojection line below.
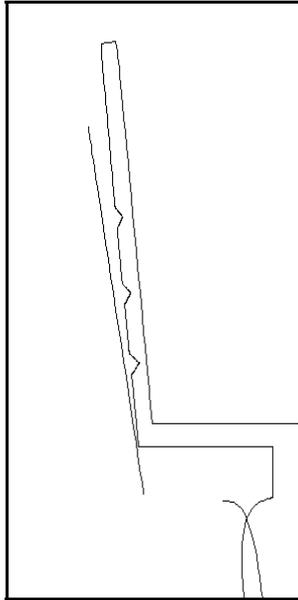
This cutter repeats around the glass a total of twelve times. So you could make a single cutter and then copy and rotate the surface created around the glass. Why not create a single surface like we did for the `Stem_cutter`. The complication is creating the cross-section curve which contains the twelve identical cuts.

Start with a circle of twelve points. Using `CURVE`⇒ `Design: Edit [O]` the `[B]` function can be used to turn the closed circle into an open curve then ten of the twelve points can be deleted leaving you with two straight line points which you know span 1/12th of an arc. Edit this curve to form the shape of one of the cutters but do **not** move either of the curve end points. It is useful to rotate the curve so that it crosses an axis so that control points can mirrored.
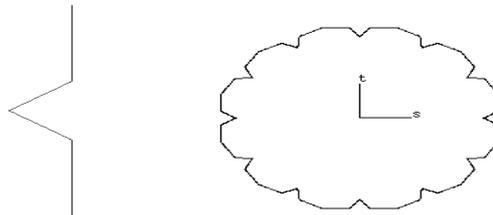
Having created one cutter we need now to repeat the curve eleven times rotating each around the origin by 30° each time (using a TEACH and EXEC series?). All that remains is to join these together to form single curve using the Curve⇒ Combine: Join All command. One curve should be created if you have not moved the end points of any of the cuts.

To complete the glass SURFACE⇒ Design: Rotate to form the Glass_cutter surface then stem TRIM⇒ Intersect: Surface the surfaces in Glass_cutter and Glass.
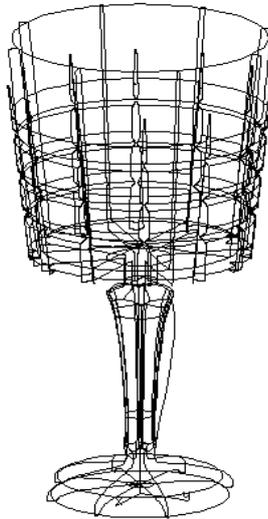
The Bump Map Alternative

The technique used to cut the glass was successful. An alternative technique could be used that is particularly applicable if the shape of the cuts are less geometric.

A bump map is a technique for creating the illusion of raised or lowered sections on a surface. Since it is an illusion only (the surfaces remain flat) this technique is no use if you need to manufacture the 'bumps' by for example machining. If a picture is the only intended output from the model then bump mapping is a valid option.

Bump maps are applied as a texture. Before they can be applied the texture needs to be created using any paint package, one that supports graduated fills is ideal. A

bump map texture is a monochrome image where variations in colour from black to white relate to variations in height from the norm of the surface. As an example if a leaf shape were to be cut into a surface the texture below would be created.
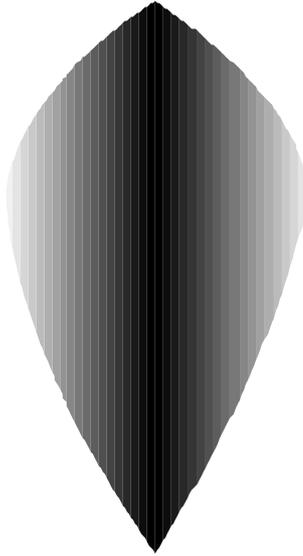
As the texture turns to black the bump map will cause the illusion of a deeper cut being made into the surface. As a practical example you could create the pattern shown below. If you do not have a suitable painting package (or you do not have the time or the inclination) a copy of this texture can be found in the `DA_texture` directory on your system. It is called `cut_pattern`. This texture can be applied as a `bump map` to the glass **surface** using `Texture⇒ Area: Create New`. Use the options to repeat 12 times around the glass using `Adaptive Mapping` and position it using the `Around` option.
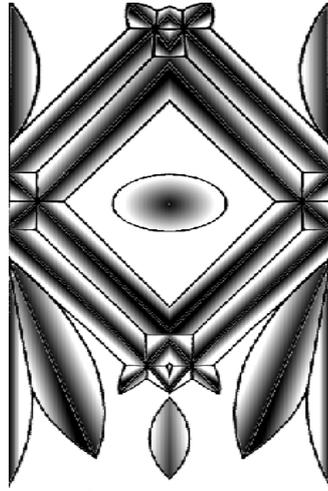
To see the result of this it will be necessary to generate a ExTrace picture. Don't forget to assign Glass material to all the surfaces first.
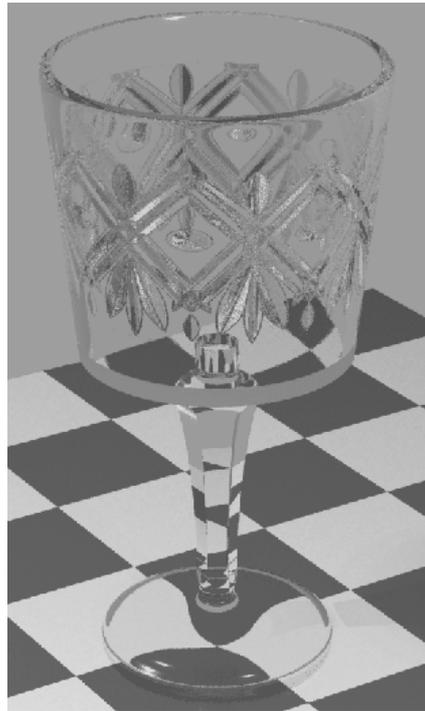
Issues covered by this exercise

- *identical repeating curves can be created in DESKARTES*

- *bump maps can be used to create the illusion of cuts*

Exercise 4 : Cutlery

No dinner table would be complete without a set of cutlery - a knife, fork and spoon. So in the next three exercises we will look at all of these, first of all, the knife.

Obviously there are many designs and basic styles of knife. Some are made out of a single piece of steel, others have a steel blade with a separately attached handle, still others have a single steel blade and handle with wooden attachments. The style of knife will of course determine the modelling method most appropriate for DESKARTES.

The styles shown above are a steak knife with a serrated blade and a wooden handle. Consider these now and note what differences the design brings to the construction method.

Cutting a Knife!

If we ignore the serration's for a moment the metal blade of the knife is an easy shape to achieve in DESKARTES. Just draw the two Xprojections (meeting at the left and right extremes of the knife) and sections shown below in an element called `Blade`.
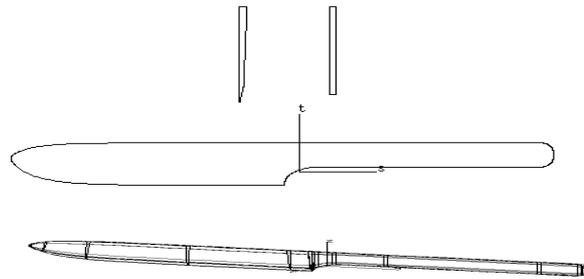
The wooden handles are also easily achieved. Draw the following two Xprojections Xprojections (again meeting at the left and right extremes of the handle) and sections in a new element called `Grip`.
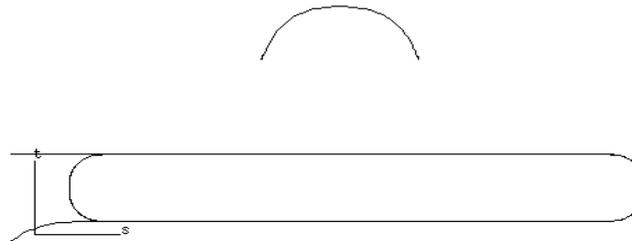
This will allow you to build one of the grip surfaces. When you are happy with the shape copy the grip **surface** and mirror the copy in X to create the second grip.

Now all that remains is to create the serration's. Have you learnt anything from the previous exercises? Yes it's time for another cutter. But what is the best way to create it? Here is one suggestion. Draw the two straight line Xprojections and the serrated Cross-section below in an element called `Serration`. Remember what we learnt about repeating curves earlier? Try and apply this in a linear fashion to the Cross-section.
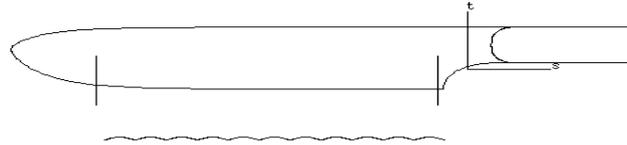
When built this will create a surface like an extrusion but since the build command has been used it allows us to create two secondary projections in the Y direction using `Build⇒ Create: Secondary Projections`. Having created the secondary projections they can then be edited to angle them across the blade surface.
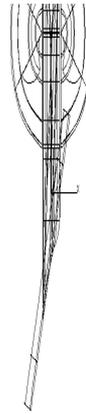
To finish the model intersect the `Serration` to the `Blade`.
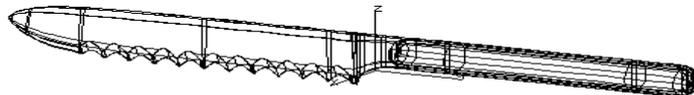
One point to note when producing the rendering of this knife. Your first reaction may be to assign the same material to the `Blade` and the `Serration's` - they are both steel after all! If you do this you may find that the serration's do not stand out. A good motto for rendering is "If at first you don't succeed - cheat!" use a slightly different material (colour?) for the `Serration's`. It's is not really a cheat in this case since the ground serration's look different to the normal chrome surface of the knife.

The Fork and Spoon

If you have understood what you have learned so far the fork and spoon should pose no problems to you. The main body of the spoon can easily be built as a single surface if the correct curves are drawn. The fork can be generated in a similar way but the prongs will need to be created using a cutter created from a Zprojection. The grip surfaces you have already created may well be used again if the design is identical by copying the original surfaces and moving the copies to a new position

Issues covered by this exercise

- *the manufacturing technique used for a product can often influence your method of creating the model in* DESKARTES

- *bump maps can be used to create the illusion of embossing*

Exercise 5 : A Casserole Dish

A casserole dish seems a easy subject to model. But even this shape can require a little thought. The problem to be solved is provided by the curvature in the lid which requires a corresponding curvature in the rim. What's your solution?

A Different Viewpoint

Let's get the easy part over first. The main bowl of the casserole dish is not unusual (if you ignore the top curvature) so model that now in an element called `Base` with an oval cross-section.
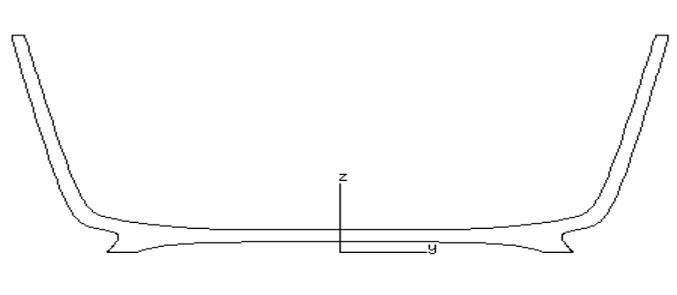

Now things get a little more interesting. The rim will need to be built as normal but the curvature means we need to approach it from a different angle - quite literally. You might normally of thought of drawing Xprojections like you did for `Base`. The best solution though is to be found by drawing Zprojections. Draw two ellipses now in a Zprojection set. Use the surface you have already created as a guide. Also draw the cross-section that is shown in the top right below.
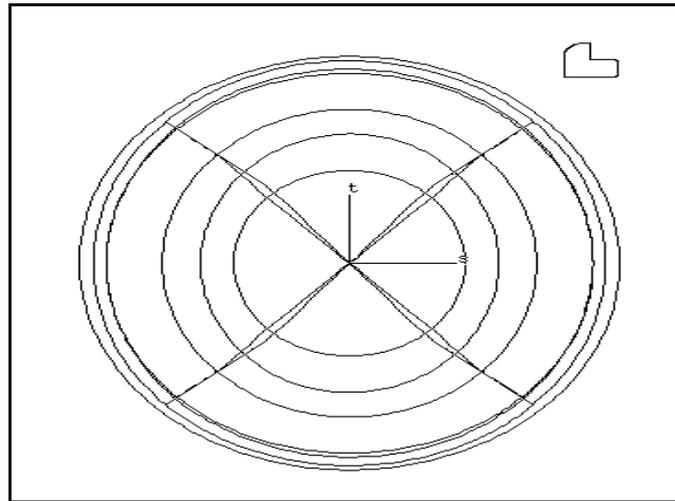
If you Build⇒Create: Surface [b] now you will see the rim is created lying on the XY plane at the bottom of Base. You should by now be familiar with a technique for creating this surface in the correct place (better than using Transform⇒Move [1]). This may give you a clue as to how to create the curvature in the rim as well.

The answer is to use secondary projections, Build⇒Create: Secondary Projections, two of them from the X direction. These curves can then first be moved up to the level of the top of the Base then edited to form the curve. When editing the curves remember that since the primary projections are closed curves the secondary projections will be closed too. You need to level the points on the front and back of the secondary curves.
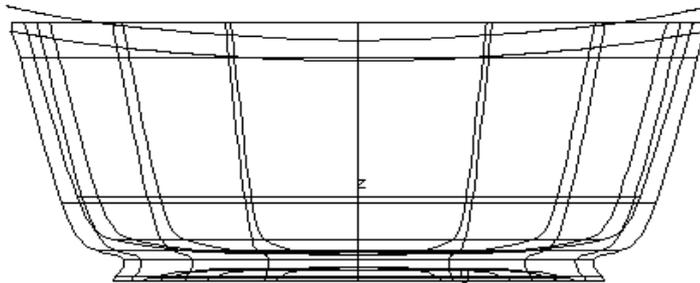

The newly built Rim and Base can now be trimmed together. Depending on the amount of curvature you have applied to the rim you may need to delete the trim curves where the Base emerges through the top of the Rim again.

The best solution for achieving the curvature on the Lid is once again to revert to the cutter technique. Build the Lid in a similar way to the Base ensuring both the primary and secondary projections are adjusted so that the Lid fits on to the Rim.
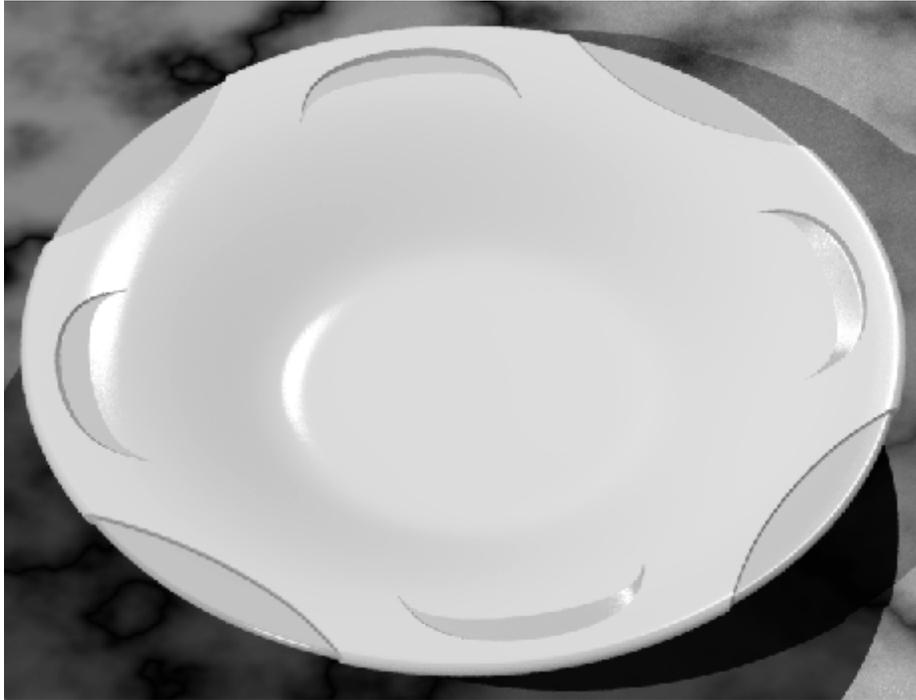
Finally create a cutter as an extrusion of an Xprojection and chop of the excess of the lid.
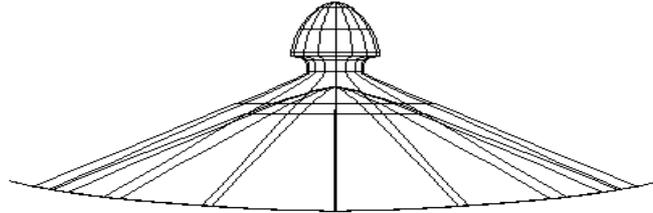
Issues covered by this exercise

- *sometime you need to look at things from a different 'angle' to build them!*

A rather unusual plate to be modelled next. How would you approach it? It's almost like two plates - one inside the other. And the arches must surely be separate surfaces.
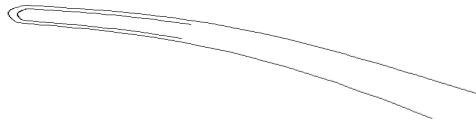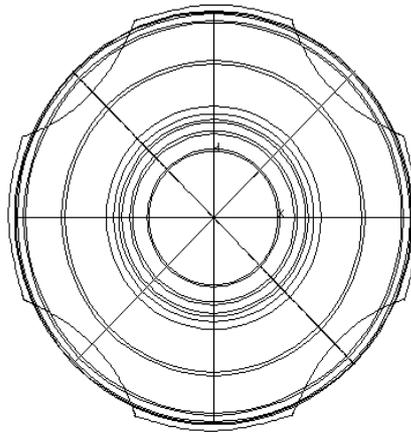
If you have taken the hint given to you the main plate should be easy. Three separate elements are required `Inner`, `Outer` and `Cutter`. Containing the curves below.
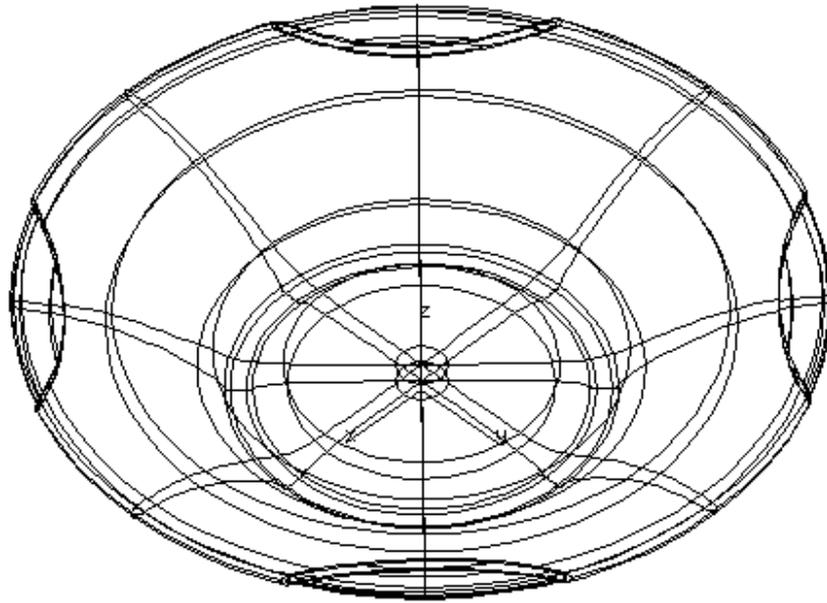
The `Outer` Xprojection.

The `Inner` Xprojection.

The `Cutter` Zprojection.

The `Inner` and `Outer` surfaces are revolved and the `Cutter` is an extrusion. The `Cutter` is trimmed (or blended) with the `Inner` and `Outer` Surfaces being sure to keep the correct parts of the surface. If you don't use TRIM⟹ `Change: Invert Cut Part` to correct your mistake.

Now for the arches. Remember it is possible to use the curves generated by trim and blend operations as the projections for the 3D building of surfaces. To start to build directly in 3D we need some trim curves. So let's make some now.

Input the **two** Zprojection curves (shown below) in a element called `feature`, (making sure that both ends of the two curves meet exactly) to describe the top and bottom of one arch. Use these curves to create two extruded surfaces that pass through the top only of the `Outer` surface. Intersect the two extruded surfaces with the body **separately, one at a time.**.
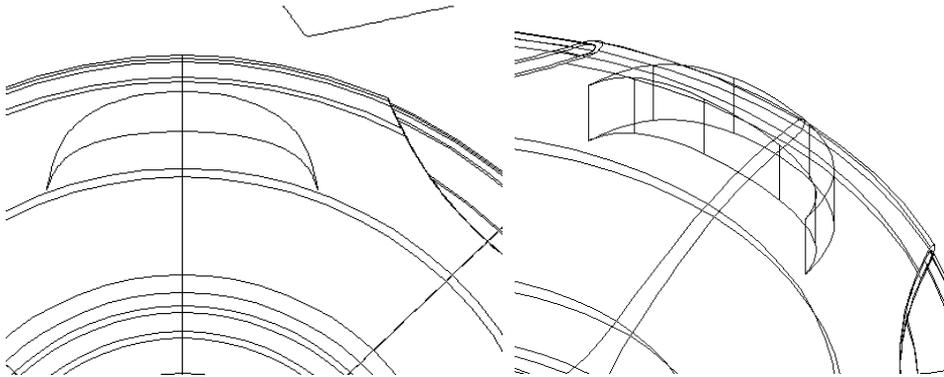
You should now have the trim curves on the extrusions as polylines needed for building the feature surface. The next stage is to make these trim curves into true 3D polylines curves using the command TRIM⇒ Change: Trim to 3D. Now create a new Projections/3D curve set in feature and Copy and Cut/Paste both the new 3D Polylines into it. Use CURVE⇒ Change: Approximate to turn each of these curves into a Bézier curve with the same number (say 20) of control points. Finally create a cross-section set in feature and input the 'tick' shaped curve shown in the top right of the first picture above.

Build the surface [b]. If the surface that is built is inverted (it sticks out of the plate) you will need to mirror the section curve and/or CURVE⇒ Change: Direction on the section.
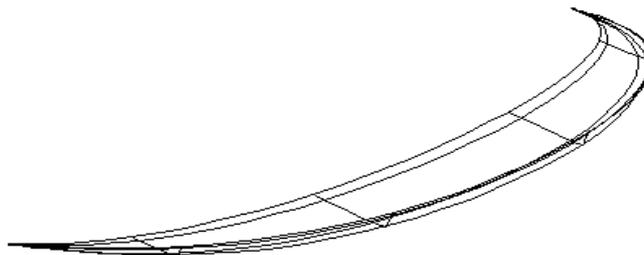
The only thing that remains is to sort out the Outer surface by using the Curve⇒ Combine: Join All command on the trim curves. The polylines are changed to polygons and two holes are cut in the body. This procedure needs to be repeated for each of the four features.
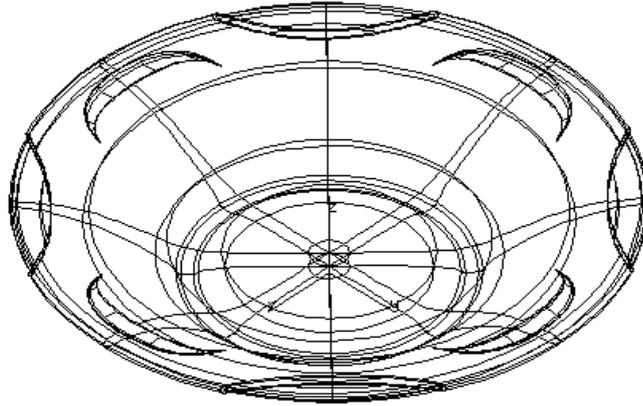
Issues covered by this exercise

•   *3D building is needed for the most complex shapes!*

Exercise 7 : A Coffee Set

The design above might be a nice way to practice what you have learned in your survey of dinner table items. No new techniques are required to complete the design. Just spend a little time using DESKARTES without the pressure of learning new techniques.