I. Spline Based Modeling - More than just another basic geometric building block.

A. Parts of a curve -

i. Control Vertex(CVs) - Used to control curvature, typically lies off the curve..

ii. Edit Points(knots) - Lies directly on the curve

iii. Hull - Network of straight lines that connect the Control Vertices.

iv. Span - Segment of a curve, between edit points.

v. Special CVs - Small **square box** indicates start of the curve, small **u** indicates direction of the curve.

vi. Key Points - Square boxes indicating key points on arcs and lines. They hold construction history, and can be edited in the Channel Box.

B. Types of curves -

i. Interpolating Splines - The curve passes directly through all of the CVs. (Place the points where you want the curve to go, but difficult to generate splines with a very smooth and gradual curvature.)

ii. Approximating Splines - Curve calculated such that it goes near, but not directly through, any of the CVs.

iii. NURBs - Non-Uniform Rational B-Spline - Shares many of the best features of a number of spline types. Like interpolating curve, it goes through the first and last control points, like an approximating curve, in does not go through the intermediate points. A set of Edit Points/Knots lies directly on the curve. *NOTE; Work with the CV's for more smoothness, use the Edit Points for more precision.*

C. Other important curve facts

i. Parameterization

a. Uniform

1. The numerical value of the first point on the curve is 0, then each edit point after that is incremented by 1. (Ranging from 0 to the total number of spans on the curve.)
2. Each span is given a value of 1, so finding a point between to edit points only requires dealing with a fraction of 1(the midpoint would be .5)
3. Uniform parameterization is very easy to work with.
4. Creating curves with CVs defaults to Uniform, if creating curves with Edit Points, you need to specify Uniform in the dialog box.

b. Chord Length

1. The numerical value of the first point on the curve is 0, then each edit point after that is proportionally set based on the chord length between the edit points.
2. Not easily edited.

ii. Degrees

1. Curves are described mathematically as polynomial equations. The degree of a curve/line is the same as the largest exponent in the equation.
2. Straight line = 1 (linear)
3. NURBs can be 1,2,3,5 and 7 (needs to be at least 3(cubic) to twist in 3D space.)
4. The higher the degree, the more CVs it takes to create the curve, and the smoother the curve becomes.

iii. Efficiency - **The fewer the spans, the more efficient, easier to work with, and faster to render.**

II. Generating Curves - Use the **Create** menu to access the CV and EP Curve Tools. Curves can be generated along the construction grids, or on selected surfaces.

A. CV Curve Tool - creates curves using control vertices.

i. Curve Degree - 3 or higher = NURBs surface.

ii. Knot Spacing - Uniform / Chord Length

iii. Multiple End Knots - set to on

a. Allows the curve to pass through the first and last CV.

b. Provides better control over your curve.

iv. You draw lines along the curve you wish to draw, emphasizing smoothness rather than precision.

B. EP Curve Tool - creates curves using edit points.

i. Can set surface degree and Knot spacing like CV curve Tool

ii. Allows you to draw your curve placing points exactly where the will lay on the curve. very precise.

C. Useful tools for creating curves
- i. Grid Snap - CVs and edit points snap to grid vertices. (Press **x** before action.)
- ii. Magnet Snap - New points snap to CVs, edit points or key points. (Press **v** before action)
- iii. MMB - allows you to move the placed CV after drawing.
- iv. **Backspace** or **Del** - allows you to delete CVs backwards allow the spline.
- v. **Insert** - allows you to continue adding CVs to a curve you deselected, while the CV Curve Tool is active.

D. Edit Curves -> Curve Edit Tool - Used to interactively edit you curves.
- i. Parameter Handle - allows you to move the editor to a particular point on the U direction of the curve.
- ii. Position handle - lets you move the chosen point on the curve and the CVs will update to suit.
- iii. Tangent and Tangent Scale Handles - let you scale and position the curves tangent.
- iv. Axes Lines - can be used to snap the tangent handle to either the X,Y, or Z axes.

E. Other helpful tools when working with Curves.
- i. Edit Curves -> Add Curve Tool - Select the curve, then place new CVs on the construction plane, grid or surface.
- ii. Edit Curves -> Reverse Curve Direction
  - a. Reverses the U direction of the curve.
  - b. Handy tool for adding points on front of curve, then simply swap back.
  - c. Used frequently when creating surfaces.
- iii. Edit Curves -> Open/Close Curve - lets you break open or close a curve.
  - a. **Shape** parameter - determines the shape of the closure.
  - b. **Keep Originals** - should be selected. This allows you to rebuild if necessary, without additional work.

F. Picking Components of a Curve
- i. While in the select mode (**q**) - select the Square, or Circle icons in the status bar.
- ii. **RMB** over the buttons will give you a menu to filter out types of points. (keep on Control Vertex and Edit Point)
- iii. **F8** to toggle between Component/Object mode in the Status Line. Component mode will give you access to the CD, EP select filters.
- iv. **RMB** in the viewing panel will give you a select Marking Menu, offer access to another pick filter.

III. Surfaces Generation- a curve moved through space, either along a straight or curved line defines a curved surface.

A. Bi-cubic patch - a curved surface created from at least two spline curves.
- i. U direction - the direction of the original curve.
- ii. V direction - the direction of the newly generated surface/form.

B. Construction History
- i. When creating a surface from a curve, Construction History allows for editing of the original curve, CVs, and edit points, changes are immediately reflected on the shape.
- ii. Construction History is easily found within the Channel Box in an objects Input Node. Edit history by changing values in the field of the input node.
- iii. This is a good technique for manipulating surfaces, but when you have the model where you want it, delete the construction history, because it takes a lot of memory to store the data. Select the object who's history you wish to delete, then **Edit -> Delete by Type -> History**.

III. Surface Creation Techniques -

A. Planar -
- i. Planar - generates a flat surface from curves on the same plane.
- ii. Non-Planar - generates a warped surface from curves that lie on different planes. (*Unavailable in Maya*)

B. Revolve - Takes a spline and revolves it around an axis to form a surface.

C. Ruled surfaces - each parameter on one curve is connected to the corresponding value on the second curve.
- i. Skin(Loft) - Requires more then 2 curves.
  - a. Similar in concept to stretching skin over a rib cage.
  - b. The order is important, and each spline has to have the same number of edit points, otherwise you end up with cross-knotting.
- ii. Patch - Requires two curves, and creates a surface between them.

D. Sweep/Extrude - Takes a curve and moves it straight through space or along a path.

IV. Surfaces - All surface generation tools can be found under the **Surfaces** menu.

A. Planar -

i. Faces can be created using **Surface -> Planar**.

ii. Surfaces can be made to have holes in them by making curves inside one another. Select them from the inside out, and then select Surface -> Planar.

iii. Using the Planar tool to create trim surfaces, allows you to use Construction history for later editing.

B. Revolve -

i. Draw a spine, offset from your axis of rotation. Select the spine, then select **Surface** -> **Revolve**. Open the dialog to set your options.

ii. Most important options are the axis of rotation(XYZ), on a local or global scale.

iii. Angle of the sweep is also available in options dialog.

C. Extrude / Swept -

i. Create a profile curve, then create a sweep path. Select the cross section, then select the extrusion path, then **Surface -> Extrude**.

ii. The extrude can begin either at the path, or at the pivot point of the profile. This is set using the **Result Position** setting.

iii. **Pivot** - lets you specify what the center of calculation should be on the profile curve. (Nearest end point, or component pivot.)

iv. **Orientation** - lets you specify how the profile curve will orient along the extrude path. (Following the path direction, or the path normal.)

v. **Style** - determines the nature of the extrude, will it bank along the path, or simply push through space with changing it's orientation.

D. Loft / Skin -

i. Create a profile curve with uniform parameterization, then duplicate several copies offset from each other.

ii. Select the profile curves in the order you wish to build the surface, then select **Surface -> Loft**.

iii. Close parameter - connects the skin from the last profile curve to the first, creating a donut effect.

iv. **Order is important**.

E. *NOTE:* When generating surfaces, for simplicity, all output geometry should be set to NURB, and all surface degree should be set to cubic.