Thoughts about router bits...

For CNC work

First things first:

Definitions:

(add illustrations)

CED: = *cutting edge diameter* or the width of the cut the tool will make through the work piece. This dimension can be in inches or MM. common inch sizes are 1/16",1/8" 3/16", 1/4", 3/8", 1/2" . Common MM sizes are...(more info needed)

CEL: = *cutting edge length* It is the maximum thickness of material it can cut. The CEL has nothing to do with the length of the bit, a 6" long bit might only be sharpened the last 1/2" giving it a 1/2"CEL. A bit with a CEL of 1/2" *MAY* be able to step cut deeper than 1/2" but it is still a CEL of 1/2"

SHK: = *shank diameter* This is the diameter of the body of the bit where it goes into the collet. SHK and CED my be the same but not always. A 1/8" bit may have a SHK of 1/4" This would mean that the CED will be 1/8" for the CEL length and then step up to the SHK diameter. Common fractional SHK sizes are 1/4" and 1/2". MM SHK diameters are: (more info needed). Collets and adapters are readily available for 1/8" SHK bits. Not as common, spindle collets are available for 3/4" bits. A larger diameter bit will deflect less and give a smoother, more accurate cut, but may limit how closely the parts can be nested.

OAL: = *overall length* This is the total length of the tool from end to end. A bit will typically go into the collet 1" or more...so a bit with a OAL of 2¼" will only extend a little more than 1" out of the collet. This would be a poor choice for cutting 1¼" material! Long OAL bits (4-6") are available, but are typically used for cutting foam where the cutting loads are light. Also, remember that the length that the bit is out of the collet reduces your max Z height that amount.

Chipload: This is simply the thickness of a chip which is formed during the machining of a material. Chipload is important because the proper size chip will carry away heat, promoting long tool life. When the chip is too small, heat is transferred to the cutting tool causing premature bit failure. Too high of a chipload will cause poor edge finish, and transfer cutting load or thrust to the part, possibly causing it to move.

Materials bits are made from:

HSS: = *High Speed Steel* A tool steel far superior to carbon steel when used for drill bits and cutting tools. A HSS drill bit could drill a hole much faster than a carbon steel bit, hence its name. Quite the innovation in the 1940's! We've moved past this type of tool steel today, HSS bits are only suitable for cutting foams.

SC: Generally just called *Solid Carbide*. A very tough wear resistant steel. Many forms of Carbide exist (silicon carbide, tungsten carbide, Beryllium carbide Etc.) as do forms with different grain size. Solid carbide router bits can vary from Crap (is this word PC?) to extreme high quality. Mass marketers can honestly say "solid carbide" and sell you total junk. If it's cheap... there's a reason. Develop a relationship with a supplier you trust! (one note of caution.. SC bits are brittle, I've had them shatter when dropped!)

Carbide Tipped: Carbide is expensive... larger diameter bits are available with chunks of carbide brazed (welded) to a steel body. This reduces the total amount of carbide used to make the bit and hopefully the price. Every thing above applies here. Generally, bits with .1" or more carbide thickness is considered a sharpen-able bit.

OTHER : There are many other exotic router bit materials available... Diamond, diamond like, poly crystalline, and more. These bit materials tend to be used in specialty, high volume, and niche markets. I hope your business grows to the point where you need to research and use these types of bits!

Bit Geometry:

Not all bits are created equal or for the same purpose or to cut the same materials. Bit geometry can affect its usefulness for a specific purpose. Lets try to sort through some major differences!

Flutes: (add illustrations)

The Number of flutes refers to the number of cutting edges that are cut into the body of the tool. More flutes increases the strength of the tool, but reduces space for chip flow. You can cut faster with a single flute tool than you can with a three flute, but the finish of the three flute will be smoother. CNC router bits are commonly available in 1, 2 and less commonly 3 flute configurations. (there are exceptions to every statement)

Shear:

The flutes of a bit can be shaped (or ground) to obtain different advantages when cutting different materials.

Straight: Straight bits have their cutting edges parallel to the body or shank of the bit. The only advantage I can come up with is cost. It's cheaper to manufacture bits this way. Exotic, expensive CNC grinding equipment is not required to make this old fashioned standby bit. I'm not aware of any brazed or carbide tipped bits that are not straight geometry bits, including shaped bits we'll talk about later.

Spiral: The flutes of this bit are ground (cut) in a helix around the shank or body of the bit. They cut with a shearing action that is smoother and with less vibration than a straight bit. A straight bit has the entire cutting edge of a flute in contact with the material being cut at the same instance in time, while a spiral flute edge has a very small contact area continuously moving or shearing during the rotation of the bit. A spiral bit always has a part of one or more flutes in contact with the material being cut, while a straight bit is only in contact while that particular flute passes by.

There are three major types of spiral bits, each has their advantages and disadvantages for particular uses.

UP CUT: The flutes on this type of spiral bit shear from the bottom up, pulling chips up, This clearing or cleaning action allows for deep cuts with less stress on the tool. The major disadvantage of this geometry is that the up-cut action can lift the part up and off whatever is holding the part on the router table. Also, up cutting action can splinter the top face of veneered or other susceptible materials

Down Cut The “down-cut” spiral bit flutes are designed to cut from the top surface down, leaving a smooth edge at the surface. It pushes down on the material being cut, and helps hold the material in place on the table surface. Some operators like this bit as it packs the sawdust in the groove being cut, this helps hold parts in position and helps maintain vacuum when that type of hold down system is used. Disadvantages are the packed sawdust is not removed by the dust collector and must be scraped or brushed off manually. Also this bit is not appropriate for thermoplastics as the "packing" of the dust re-welds the parts together. When making "through cuts" the down cutting force can splinter the bottom face of veneered or other susceptible materials

Compression: The third type of spiral bit is a hybrid design of the up and down cut bit. This bit has a up cut portion on the lower part of the bit and down cut on the remainder of its CEL. Material being cut is augured downward from the top of the material and upward from the bottom. This compression of cutting forces results in a clean, splinter free top and bottom face. A special type of compression bit is the **Mortise** compression. this style has a much shorter up-cut section than the standard compression bit and is used for grooving and dadoing as shallow as ¼" while still having a splinter free top surface.

There are other variations of these three types, one involves the angle of the helix, fine tuning the bit for particular materials.

Bit ends:

Some router bits are designed for plunge cutting and some are not.

Standard bits will plunge cut nicely, these bits can be identified by the swallow tail style profile of the end of the bit. This bit is the right choice when cutting profiles. The disadvantage of this style bit is it leaves marks or swirls when pocket cutting.

FEM: full end mill? flat end mill? this style of end geometry is designed to cut a smooth bottom surface when pocketing. The disadvantage of this style is it need to be ramped into its cut. Forgetting to do this will result in a burned bit. The end profile of this bit is flat.

Ball end:

Other:

O flute: This is a relatively new wrinkle in bit geometry. The gullets of the O flute bit are designed to "roll" the shavings into a ball. The purpose of this property is to compact the shavings and make them easier to throw clear of the bit. This property is especially important when cutting materials that create lightweight shavings... like plastics.

Shaped bits:

This category of bits will include any bit that is not intended to cut a straight profile. The most common for CNC users will be the V-bits, next the plunge shape cutters for faux raised panel doors followed by any number of specialty bits (like toy train track bits). Somewhere in this discussion it needs to be said... NEVER use a ball bearing or piloted bit in a CNC router. The computer/CNC equipment is "piloting" the bit, using one will result in interference between the bit and the equipment and yield lost steps, damaged parts or worse!

V-bits: Come in many flavors, and are typically used for signs and V-carving (a topic worthy of its own write-up) some things that affect how they are used are:

Angle: measured as the included angle, v-bits are commonly available in 30°, 45°, 60°, 90°, and 120°. the tip of a V-bit can come to a point, a small radius or a flat.
Diameter: measured perpendicular to the shank, this is the width of a full depth cut at the surface of the material.

Form bits: This is a wide open category... the only restriction I'm aware of is it must be able to plunge. Some of these bits remind you of the ogee and radius combo bits used with a bearing pilot... only there's a flat or radius or point where you might expect a pilot. often these bits are used for decorative grooves and in combinations to create faux raised panel doors in MDF.

Spoil board cutters: not sure where to categorize these bits... One might argue that they are a form bit shaped to cut a large rabbet. Not a plunge style bit, but designed for a smooth bottom cut, they generally have a small radius to help smooth the transition between step-overs.

Ball end taper: another conundrum... a special straight bit (its not straight)... or a special form bit (very little form). Typically these bits have a 1° taper on each side. The feature of these bits is that a ⅛" bit can have the reach and strength of a ¼" bit. They are generally used for 3D detail carving. When used with about a 7-10% step over, the ball end gives a very smooth finish, blending the cutter paths together.

What did I leave out?