Engineering Sketch Pad (ESP)

Training Session 4
CSM Language (1)

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Overview

- Format of `.csm` file
- Special characters
- Numbers
- Parameters
  - Types
  - Names
  - Dimensions
  - Lower and Upper Bounds
- Expressions
  - Numeric
  - String
- Reading Help File
- CSM File Editor

Opening Thoughts

- All configuration information is contained in `.csm` (or possibly `.udc`) files
  - `.csm` files are plain ASCII text that are readable by humans
  - because they are ASCII files, they can either be written directly by humans (using any text editor) or by other programs
- When you build a configuration using the `ESP` user interface, you are actually building a `.csm` file
- Using the interface can be effective for beginning users who are building small models
- Once a user gets experience with `ESP`, most of the models are created by "typing" a `.csm` directly

Format of the `.csm` file (1)

- The `.csm` file contains a series of statements.
- If a line contains a hash (#), all characters starting at the hash are ignored.
- If a line contains a backslash (\), all characters starting at the backslash are ignored and the next line is appended; spaces at the beginning of the next line are treated normally.
- All statements begin with a keyword (described below) and must contain at least the indicated number of arguments.
- The keywords may either be all lowercase or all UPPERCASE.
- Any CSM statement can be used in a `.csm` file except the `INTERFACE` statement.

Format of the `.csm` file (2)

- Blocks of statements must be properly nested. The Blocks are bounded by
  - `PATBEG/PATEND`
  - `IFTHEN/ELSEIF/ELSE/ENDIF`
  - `SKBEG/SKEND`
  - `SOLBEG/SOLEND`
  - `CATBEG/CATEND`
- Extra arguments in a statement are discarded. If one wants to add a comment, it is recommended to begin it with a hash (#) in case optional arguments are added in future releases.
- Any statements after an `END` statement are ignored.
  - hint: if debugging, consider THROWing an error instead to avoid unclosed Blocks
- All arguments must not contain any spaces or must be enclosed in a pair of double quotes (for example, `"a + b"`).

Format of the `.csm` file (3)

- Parameters are evaluated in the order that they appear in the file, using MATLAB-like syntax (see 'Expression rules' below).
- During the build process, `OpenCSM` maintains a last-in-first-out (LIFO) "Stack" that can contain Bodys, Marks, and Sketches.
- The `.csm` statements are executed in a stack-like way, taking their inputs from the Stack and depositing their results onto the Stack.
- The default name for each Branch is `Brch_xxxxxx`, where `xxxxxx` is a unique sequence number.

Special characters (1)

```
#               introduces comment
"               ignore spaces until following "
\               ignore this and following characters and
                   concatenate next line
<space>         separates arguments in .csm file (except
                   between " and ")
0-9             digits used in numbers and in names
A-Z a-z         letters used in names
_ : @           characters used in names (see rule for names)
.               decimal separator (used in numbers),
                   introduces dot-suffixes (in names)
,               separates function arguments and row/column
                   in subscripts
;               multi-value item separator
```

Special characters (2)

```
( )          groups expressions and function arguments
[ ]          specifies subscripts in form [row,column] or [index]
{ } < >      characters used in strings
+ - * / ^    arithmetic operators
$            as first character, introduces a string that is
                terminated by end-of-line or un-escaped plus,
                comma, or close-parenthesis
@            as first character, introduces @-parameters
'            used to escape comma, plus, or close-parenthesis
                within strings
!            if first character of implicit string, ignore
                $! and treat as an expression

|            cannot be used (reserved for OpenCSM internals)
~            cannot be used (reserved for OpenCSM internals)
&            cannot be used (reserved for OpenCSM internals)
```

Numbers

- Start with a digit or decimal (.)
- Followed by zero or more digits and/or decimals (.)
- There can be at most one decimal in a number
- Optionally followed by an e, e+, e-, E, E+, or E-
- If there is an e or E, it must be followed by one or more digits
- If numbers are in a list, the elements are separated by a semicolon (;)

Types of Parameters (1)

- Design Parameter
  - values are declared in a `DESPMTR` statement
    - in `.csm` file or
    - in top-level include-type `.udc` file
  - must contain one or more numbers (no strings)
  - if multi-valued, must be first `DIMENSION`ed
  - can contain lower- and upper-bounds, specified in `LBOUND` and `UBOUND` statements
  - values are only visible at the top-level
  - values can be changed by a call to `ocsmSetValu` or `ocsmSetValuD` (after `ocsmLoad` and before `ocsmBuild`)
  - values can be read by call to `ocsmGetValu`
  - sensitivities can be computed by a call to `ocsmSetVel` or `ocsmSetVelD`

Types of Parameters (2)

- Configuration Parameter
  - values are declared in a `CFGPMTR` statement
    - in `.csm` file or
    - in top-level include-type `.udc` file
  - must contain one or more numbers (no strings)
  - if multi-valued, must be first `DIMENSION`ed
  - can contain lower- and upper-bounds, specified in `LBOUND` and `UBOUND` statements
  - values are only visible at the top-level
  - values can be changed by a call to `ocsmSetValu` or `ocsmSetValuD` (after `ocsmLoad` and before `ocsmBuild`)
  - values can be read by call to `ocsmGetValu`
  - sensitivities CANNOT be computed for Configuration Parameters

Types of Parameters (3)

- Constant Parameter
  - values are declared in a `CONPMTR` statement
    - in `.csm` file
    - in top-level include-type `.udc` file
  - must contain only one number (no strings)
  - values are visible from any `.csm` or `.udc` file
  - values CANNOT be changed by a call to `ocsmSetValu` or `ocsmSetValuD`
  - sensitivities CANNOT be computed for Constant Parameters

Types of Parameters (4)

- Local Variables
  - is created by a `SET`, `PATBEG` or `GETATTR` statement
  - can contain one or more numbers or a character string
  - if multi-valued, must first be `DIMENSION`ed
  - can be an @-parameter (described below)
  - are only usable in `.csm` or `.udc` file in which it was defined (unless the `.udc` file has `INTERFACE . ALL` in its preamble)
- Output Parameters
  - declared in a `OUTPMTR` statement
  - refers to any local variable whose value is available outside `ESP` (such as to `CAPS`)

Parameter Type Summary

	DESPMTR	CFGPMTR	CONPMTR	OUTPMTR	LOCALVAR
Can be vector or array of numbers	Y	Y	N	Y	Y
Can have a string value	N	N	N	Y	Y
Can be restricted by `LBOUND` or `UBOUND`	Y	Y	N	N	N
Scope	T	T	G	L	L
Defined during `ocsmLoad` or `ocsmLoadDict`	Y	Y	Y	N	N
Can be set via `ocsmSetValu(D)`	Y	Y	N	N	N
Defined and set during `ocsmBuild`	N	N	N	Y	Y
Can be read via `ocsmGetValu(S)`	Y	Y	Y	Y	Y*
Can find associated sensitivity	Y	N	N	N	N

Y*=Parameter index may be different for different builds

scopes: T=top-level, G=global, L=local

Notes on the `DIMENSION` Statement

- General form is: `DIMENSION $pmtrName nrow ncol`
- Can only be applied once to a `DESPMTR` or `CFGPMTR`
- Cannot be applied to a `CONPMTR`
- When applied to an `OUTPMTR` or `LOCALVAR`
  - if the new size has fewer elements than the old size
    - the old values are copied to fill the new size
    - extra old elements are lost
  - if the new size has more elements than the old size
    - the old values are all copied
    - the last old value is copied into all the remaining new locations

Valid Parameter Names

- Start with a letter, colon (:), or at-sign (@)
- Contains letters, digits, at-signs (@), underscores (_), and colons (:)
- Contains fewer than 64 characters
- Names that start with an at-sign cannot be set by a `CONPMTR`, `DESPMTR`, `CFGPMTR`, `SET`, or `PATBEG` statement
- When listed in `ESP`, are sub-grouped based upon the colons (:)

Dot-suffixes

- If a name has a dot-suffix, a property of the parameter (and not its value) is returned

`x.nrow`	number of rows in `x` (0 for string)
`x.ncol`	number of columns in `x` (0 for string)
`x.size`	number of elements or characters in `x`
`x.sum`	sum of elements in `x`
`x.norm`	RMS norm of elements in `x`
`x.min`	minimum value in `x`
`x.max`	maximum value in `x`

- Example:

```
DIMENSION  myvar  2 3 1
DESPMTR    myvar  "1; 2; 3;\
                   4; 5; 6"
```

  - `myvar.nrow` returns 2
  - `myvar.sum` returns 21

Accessing Element of an Array

- Basic format is: `name[irow,icol]` or `name[ielem]`
- Name must follow rules above
- `irow`, `icol`, and `ielem` must be valid expressions
- `irow`, `icol`, and `ielem` start counting at 1
- For 2D arrays, either `name[irow,icol]` or `name[ielem]` be used
- Values are stored across rows ([1,1], [1,2], ..., [2,1], ...)

@-parameters (1)

- Every time a Body gets created, or after a `SELECT` statement, readable local variables are set

@-parameters (2)

```
        body face edge node  <- last SELECT
@seltype -1    2    1    0   selection type (0=node,1=edge,2=face)
@selbody  x    -    -    -   current Body
@sellist -1    x    x    x   list of Nodes/Edges/Faces

@nbody    x    x    x    x   number of Bodys
@ibody    x    x    x    x   current   Body
@nface    x    x    x    x   number of Faces in @ibody
@iface   -1    x   -1   -1   current   Face  in @ibody
@nedge    x    x    x    x   number of Edges in @ibody
@iedge   -1   -1    x   -1   current   Edge  in @ibody
@nnode    x    x    x    x   number of Nodes in @ibody
@inode   -1   -1   -1    x   current   Node  in @ibody
@igroup   x    x    x    x   group of current Body
@itype    x    x    x    x   0=NodeBody, 1=WireBody,
                                        2=SheetBody, 3=SolidBody
@nbors   -1    x    -    x   number of incident Edges
@nbors   -1    -    x    -   number of incident Faces
```

@-parameters (3)

@ibody1	-1	x	x	-1	first element of 'Body' Attribute in @ibody
@ibody2	-1	x	x	-1	second element of 'Body' Attribute in @ibody
@xmin	x	x	*	x	x-min of bounding box or x at beg of edge
@ymin	x	x	*	x	y-min of bounding box or y at beg of edge
@zmin	x	x	*	x	z-min of bounding box or z at beg of edge
@xmax	x	x	*	x	x-max of bounding box or x at end of edge
@ymax	x	x	*	x	y-max of bounding box or y at end of edge
@zmax	x	x	*	x	z-max of bounding box or z at end of edge
@length	0	0	x	0	length of edge
@area	x	x	0	0	area of face or surface area of body
@volume	x	0	0	0	volume of body (if a solid)
@xcg	x	x	x	x	location of center of gravity
@ycg	x	x	x	x	
@zcg	x	x	x	x	

@-parameters (4)

```
@Ixx      x     x     x     0   centroidal moment of inertia
@Ixy      x     x     x     0
@Ixz      x     x     x     0
@Iyx      x     x     x     0
@Iyy      x     x     x     0
@Iyz      x     x     x     0
@Izx      x     x     x     0
@Izy      x     x     x     0
@Izz      x     x     x     0

@signal   x     x     x     x   current signal code
@nwarn    x     x     x     x   number of warnings

@edata                          only set up by EVALUATE statement
@stack                          Bodys in stack: 0=mark, -1=none
@version                        version number

in above table:
   x -> value is set
   - -> value is unchanged
   * -> special value is set (if edge)
   0 -> value is set to  0
  -1 -> value is set to -1
```

Expression Rules (Valid operators)

- Valid operators (in order of precedence):

( )	parentheses, inner-most evaluated first
func(a,b)	function arguments, then function itself
$\wedge$	exponentiation (evaluated left to right)
* /	multiply and divide (evaluated left to right)
+ -	add and subtract (evaluated left to right)

String Variables

- Contains the sequence of characters starting after a dollar-sign($) and ending with a space, plus-sign (+), comma (,), or closed-parenthesis ())
- If escaped with an apostrophe (’), can contain a plus-sign (’+), comma (’,) or closed-parenthesis (’))
  - for example:

    `$thisStringContainsAComma(’,’)`

    returns `thisStringContainsAComma(,)`
- Can never contain a space
- Are parsed left-to-right, as is any expression
  - for example:

```
SET    one 1
SET    mystr $thereIsA+one+$inThisString
```

    returns (in `mystr`) `thereIsA1inThisString`

Functions (1)

`pi(x)`	3.14159...*x
`min(x,y)`	minimum of x and y
`max(x,y)`	maximum of x and y
`sqrt(x)`	square root of x
`abs(x)`	absolute value of x
`int(x)`	integer part of x ($3.5 \rightarrow 3$, $-3.5 \rightarrow -3$)
	produces derivative=0
`nint(x)`	nearest integer to x
	produces derivative=0
`ceil(x)`	smallest integer not less than x
	produces derivative=0
`floor(x)`	largest integer not greater than x
	produces derivative=0

Functions (2)

`mod(a,b)`	modulus(a/b), with same sign as a and b$\geq$0
`sign(test)`	returns -1, 0, or +1
	produces derivative=0
`exp(x)`	exponential of x
`log(x)`	natural logarithm of x
`log10(x)`	common logarithm of x

Functions (3)

`sin(x)`	sine of x	(in radians)
`sind(x)`	sine of x	(in degrees)
`asin(x)`	arc-sine of x	(in radians)
`asind(x)`	arc-sine of x	(in degrees)
`cos(x)`	cosine of x	(in radians)
`cosd(x)`	cosine of x	(in degrees)
`acos(x)`	arc-cosine of x	(in radians)
`acosd(x)`	arc-cosine of x	(in degrees)

Functions (4)

`tan(x)`	tangent of x	(in radians)
`tand(x)`	tangent of x	(in degrees)
`atan(x)`	arc-tangent of x	(in radians)
`atand(x)`	arc-tangent of x	(in degrees)
`atan2(y,x)`	arc-tangent of y/x	(in radians)
`atan2d(y,x)`	arc-tangent of y/x	(in degrees)
`hypot(x,y)`	hypotenuse: $\sqrt{x^2+y^2}$	
`hypot3(x,y,z)`	hypotenuse: $\sqrt{x^2+y^2+z^2}$	

Functions (5)

`Xcent(xa,ya,dab,xb,yb)`	X-center of circular arc produces derivative=0
`Ycent(xa,ya,dab,xb,yb)`	Y-center of circular arc produces derivative=0
`Xmidl(xa,ya,dab,xb,yb)`	X-point at midpoint of circular arc produces derivative=0
`Ymidl(xa,ya,dab,xb,yb)`	Y-point at midpoint of circular arc produces derivative=0
`seglen(xa,ya,dab,xb,yb)`	length of segment produces derivative=0

Functions (6)

`incline(xa,ya,dab,xb,yb)`	inclination of chord (in degrees) produces derivative=0
`radius(xa,ya,dab,xb,yb)`	radius of curvature (or 0 for linseg) produces derivative=0
`sweep(xa,ya,dab,xb,yb)`	sweep angle of circular arc (in degs) produces derivative=0
`turnang(xa,ya,dab,...` `  xb,yb,dbc,xc,yc)`	turning angle at b (in degrees) produces derivative=0
`dip(xa,ya,xb,yb,rad)`	acute dip between arc and chord produces derivative=0
`smallang(x)`	ensures $-180 \leq x \leq 180$

Functions (7)

`val2str(num,digits)`	convert `num` to a string
`str2val(string)`	convert `string` to a number
`findstr(str1,str2)`	finds location of `str2` in `str1` (bias-1) or 0 if not found
`slice(str,ibeg,iend)`	substring of `str` from `ibeg` to `iend` (bias-1)
`path($pwd)`	returns present working directory
`path($csm)`	returns directory of current `.csm` file
`path($root)`	returns $ESP_ROOT
`path($file)`	returns name of `.csm` file

Functions (8)

`ifzero(test,ifTrue,ifFalse)`	if `test` $= 0$, return `ifTrue`, else return `ifFalse`
`ifpos(test,ifTrue,ifFalse)`	if `test` > 0, return `ifTrue`, else return `ifFalse`
`ifneg(test,ifTrue,ifFalse)`	if `test` < 0, return `ifTrue`, else return `ifFalse`
`ifnan(test,ifTrue,ifFalse)`	if `test` is NaN, return `ifTrue`, else return `ifFalse`

Reading Help File (1)

```
STORE      $name index=0 keep=0
           use:    stores Group on top of Stack
           pops:   any
           pushes: -
           notes:  Sketch may not be open
                   Solver may not be open
                   $name is used directly (without evaluation)
                   previous Group in name/index is overwritten
                   if $name=.   then Body is popped off stack
                                     but not actually stored
                   if $name=..  then pop Bodys off stack back
                                     to the Mark
                   if $name=... then the stack is cleared
                   if keep==1, the Group is not popped off stack
                   cannot be followed by ATTRIBUTE or CSYSTEM
                   signals that may be thrown/caught:
                      $insufficient_bodys_on_stack
```

Reading Help File (2)

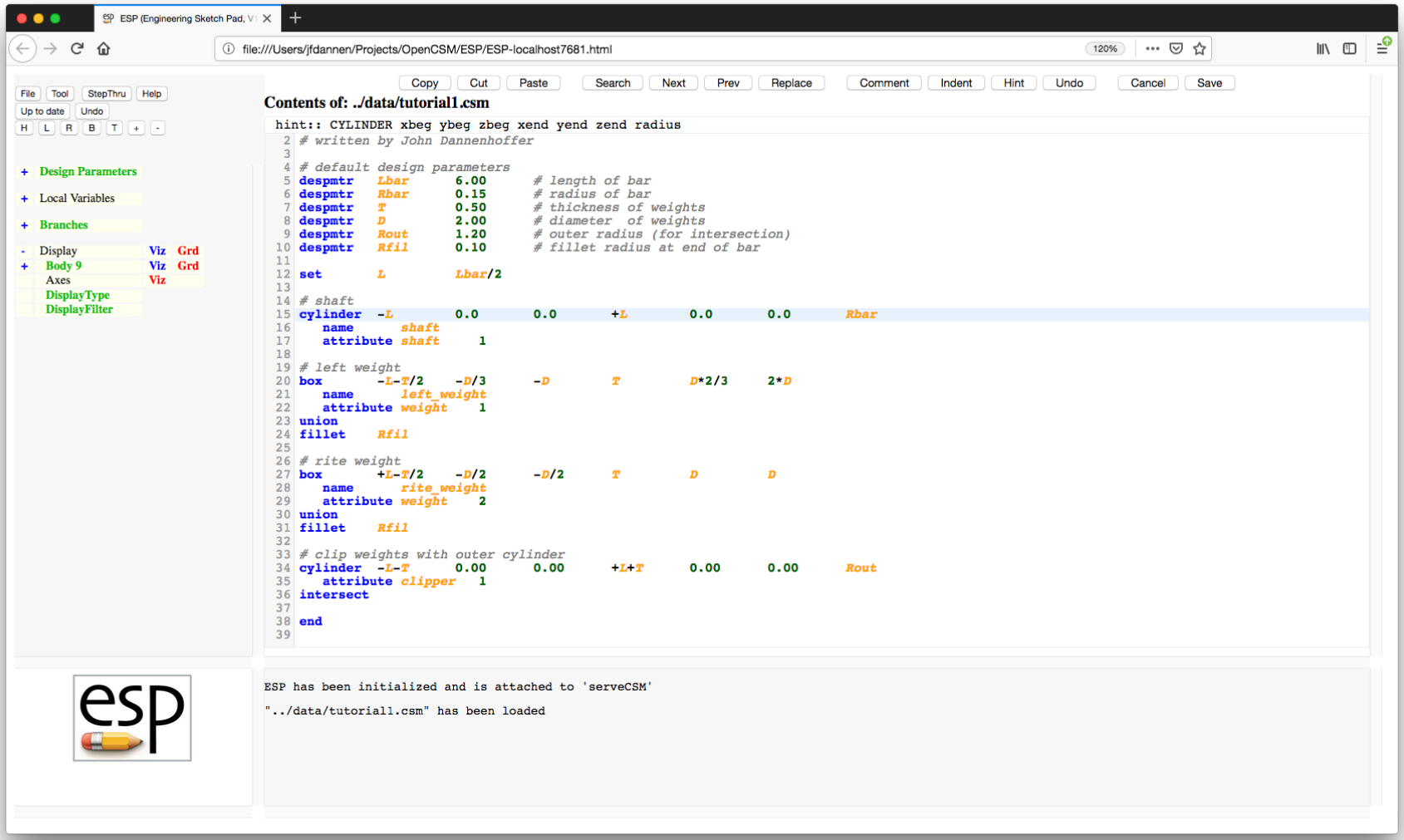
- If argument starts with dollar-sign ($), then the argument is assumed to be string, and the user does not need to prepend the argument with a dollar-sign ($)
  - if an expression is given that should be evaluated (to a string value), prepend the argument with an exclamation point (!), as in:

```
SET    i 10
STORE  !$ThisIsBody+i+$.
```

    stores the Body in a location named `ThisIsBody10.`
- For arguments that are listed with an equal-sign (=), the value after the equal sign is the default value

CSM File Editor (1)

- Started via the button **File→Edit:**



CSM File Editor (2)

- Options (on top row) include:
  - **Copy** — copy highlighted text into paste-buffer
  - **Cut** — copy highlighted text into paste-buffer and remove it from the file
  - **Paste** — copy paste-buffer into `.csm` file at the cursor
  - **Insert** — insert the contents of the named file at the cursor
  - **Search** — search for text (input is on top line)
  - **Next** — search for next occurrence
  - **Prev** — search for previous occurrence
  - **Replace** — replace one text string with another
  - ...

CSM File Editor (3)

- Options on top row include:
  - ...
  - **Comment** — if first statement in highlighted region is not a comment, block comment the whole region. Otherwise, block un-comment the whole region
  - **Indent** — indent the highlighted region
  - **Hint** — provide a hint (on the top line) for the statement at the cursor
  - **Undo** — un-do the previous edit
  - **Cancel** — leave the editor (and lose your changes)
  - **Save** — save the file to disk. If there is only one file in the session, the configuration is also automatically re-built