

ASEN 5331 - HW4

James Wright

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0.1 Meaning of n . . .

Term	Definition	Source/Relevant Reference
<code>nsd</code>	number of spacial dimensions	<code>common/common.h#343</code>
<code>nflow</code>	number of flow variables (ie. size of \mathbf{Y})	?
<code>nshape</code>	number of interior element shape functions	<code>common/common.h#444</code>
<code>ngauss</code>	number of interior element integration points	<code>common/common.h#447</code>
<code>npro</code>	number of elements processed in a single call of <code>e3.f</code>	Jansen lecture
<code>npro</code>	number of virtual processors for the current block	<code>common/common/h#586</code>
<code>nen</code>	maximum number of element nodes	<code>common/common.h#341</code>
<code>nQpt</code>	number of quadrature points per element	<code>common/shp4t.f#14</code>
<code>nshl</code>	number of shape functions per element	<code>common/genblkPosix.f#70</code>
<code>nshg</code>	global number of shape functions	<code>common/common.h#354</code>
<code>nenl</code>	number of element nodes for current block	<code>common/common.h#382</code>
<code>nedof</code>	total number of degrees of freedom	<code>common/e3.f#35,344</code>

1 Essential Boundary Conditions

1.1 Setting BC Values

In `compressible/itrbc.f`

$\mathbf{Y} = \mathbf{y}$

$g(x) = \text{BC on a per node basis}$

The essential boundary conditions are set in `/compressible/itrbc.f#59-198`. The `iBC` variable contains bit-wise information on what specific boundary conditions are going to be set. `BC` contains the BC data ($g(x)$ in the notes) for each individual node. `iBC` is set in `common/genibc.f` and `BC` is set in `common/genbc.f`, which takes `iBC` as an input.

Essentially, the code checks `iBC` for which values of \mathbf{Y} should be set. This logical check is done via the `ibits()` function. If a given \mathbf{Y} chosen, then \mathbf{Y} is set to the corresponding value in `BC`.

So `common/gendat.f->gendat()` calls `common/genibc.f->geniBC()` to create the `iBC` vector. `common/gendat.f` then calls `common/genbc.f->genBC()` to create the `BC` vector which contains the values that should then be substituted into the `y` array in `compressible/itrbc.f`.

1.2 Applying S Matrices

The application of the S matrices applied in two different locations: `compressible/b3res.f` and `compressible/b3lhs.f`, which apply S to the residual (`res`, RHS) and mass matrix (`EGMass`, LHS) respectively.

For the residual, the values of `res` are replaced based on the logical output from the same `ibits()` operation on `iBC` as before, similar to when `BC` values were set in `common/genbc.f` → `genBC()`. This process occurs in `compressible/b3res.f#28-163`.

Applying S on the LHS operates in a nearly identical way.

2 Natural Boundary Conditions

There are 6 different flux components: normal flux h^m , pressure flux h^p , viscous stress/traction vector h_j^v , and heat flux h^h .

`iBCB` is the equivalent of `IBC` for natural boundary conditions; it stores, bit-wise, which fluxes are to be set.

`BCB` stores the h^j values. The last index of the array represents the 6 flux components:

Index	Variable	Description
1	h^m	mass/normal flux
2	h^p	pressure flux
3	h_1^v	viscous flux in x1 direction
4	h_2^v	viscous flux in x2 direction
5	h_3^v	viscous flux in x3 direction
6	h^h	heat flux

`compressible/e3bvar.f#85-128` first computes the flow variable values at the quadrature points, `pres`, `T`, `u1`, `u2`, `u3`, `rho`, `ei`, `rk`. These values are used to set the “floating” fluxes (ie. fluxes on $\Gamma - \Gamma_h^j$). This also computes the user defined flux values h^j at quadrature points and puts them into `rou`, `p`, `Fv1`, `Fv2`, `Fv3`, `heat` for the components of `BCB`.

`compressible/e3b.f` sets a series of flux vectors `F1`, `F2`, `F3`, `F4`, `F5` which correspond to the 5 fluxes of the primitive equation (density flux, 3 velocity fluxes, and a temperature flux). These fluxes are either set to their “floating” values or the user specified flux values, as determined by the value of `iBCB`. The `e3b()` routine also defines `Fv2`, `Fv3`, `Fv4` and `Fv5` as parts of the viscous flux, which are then used for creating other fluxes (for example, part of the energy flux is simply $u_i \tau_{ij}$).

Once the `F1`, `F2`, `F3`, `F4`, `F5` variables are set, they are then put into the residual `r1` in `compressible/e3b.f#266-292`.