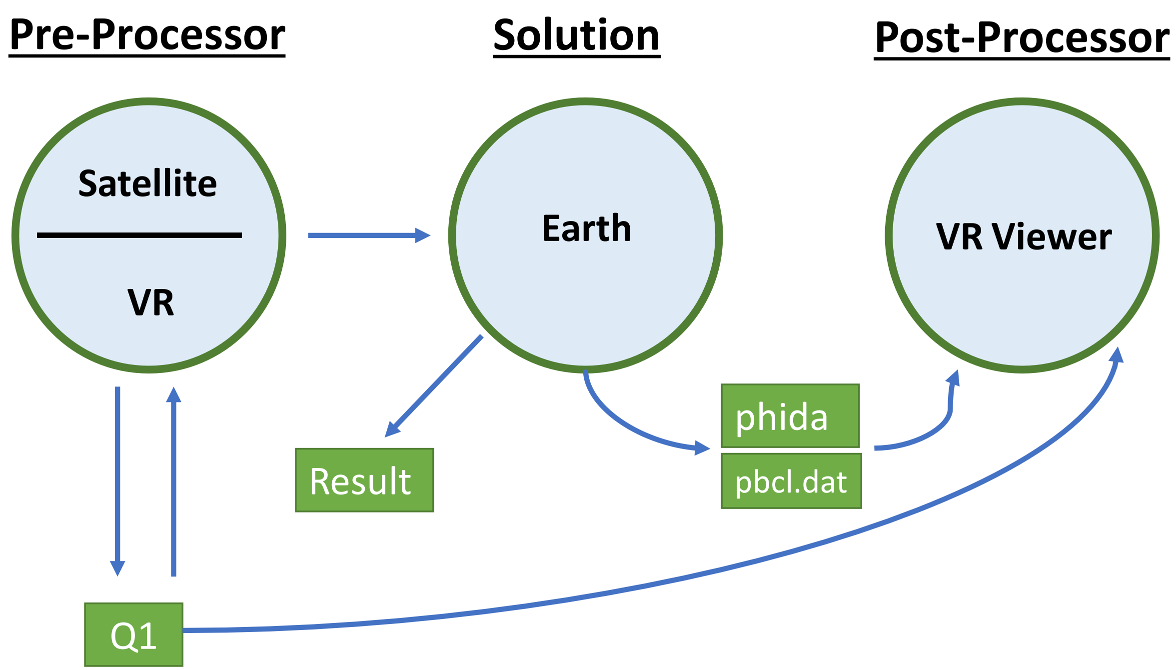
CHAM

PHOENICS Fundamentals

File Handling



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File Handling

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- "<u>Save as a Case</u>"

q1
result
phida
pbcl.dat
gxmoni.png

casename.q1
casename.res
casename.pda
casename.dat
casename.png

File Handling

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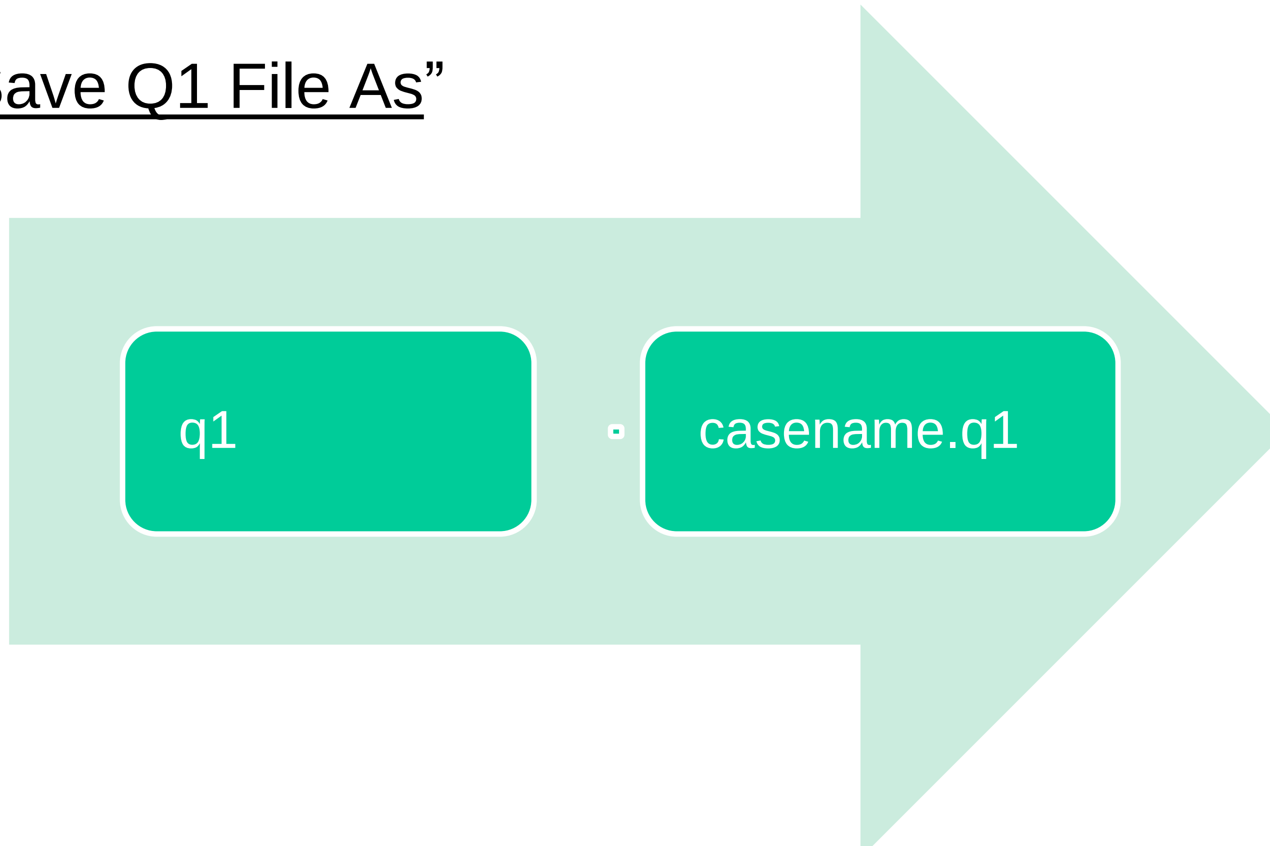
- “Save Q1 File As”



- Use this frequently to save during model set-up.

File Handling

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- “Open Existing Case”

casename.q1
casename.res
casename.pda
casename.dat
casename.png

q1
result
phida
pbcl.dat
gxmoni.png

Variables

- A “variable” has a value in every cell in the domain.

Pressure	P1
Velocity components	U1, V1, W1
Temperature	TEM1
Radiation temperature	T3
Turbulence variables	KE, EP
General concentration	C1
Smoke concentration	SMOK
Density	DEN1
Turbulent viscosity	ENUT
Mass flow rate	R1

Types of Grid

- PHOENICS grids are structured -
  cells are topologically Cartesian brick elements.
- PHOENICS grids may be :
  - Cartesian
  - Cylindrical-polar
  - Body fitted, orthogonal or non-orthogonal
- The grid distribution in x,y,z can be non-uniform.

- For cylindrical-polar coordinates, the following orientation is always used:
  - x is the angular direction
  - y is the radial direction
  - z is the axial direction

Storage

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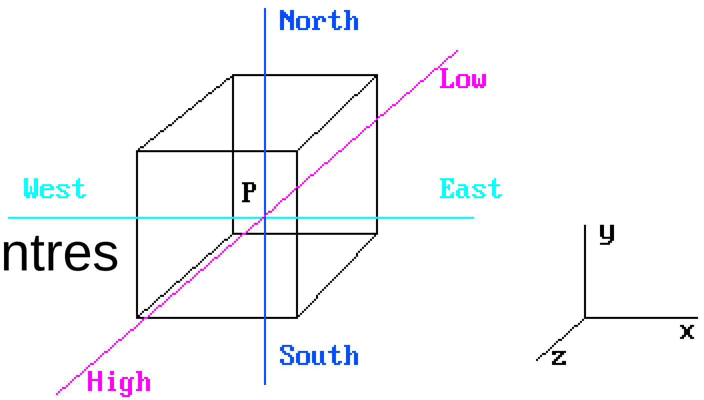
- Variables are stored at the centre points of cells, with values supposedly typical of the whole cell; BUT
- Velocity components are stored at the centre points of the <u>cell faces</u>.



- P = Cell centre
- N,S,E,W,H,L = Neighbour-cell centres
- S -> N = Positive IY
- W -> E = Positive IX
- L -> H = Positive IZ
- T = Cell centre at previous time step

- An array of cells with the same IZ is referred to as a SLAB.

The PHOENICS Equations

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- PHOENICS solves a set of conservation equations which govern the flow.
- These include:
  - conservation of mass
  - conservation of momentum in each of x/y/z
  - conservation of energy
- The basic balance, or conservation equation is just:

Outflow from cell = Inflow into cell

+ net source within cell

+ change in value during time step

The Conservation Equation

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- Mathematically, the conservation equations are:

$$\frac{\partial}{\partial t}(\rho\phi) + \nabla.(\rho\mathbf{u}\phi) = \nabla.(\Gamma\nabla\phi) + S,$$

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- ϕ - the conserved variable in question
- ρ - density
- $\mathbf{u}$ - vector velocity
- Γ - diffusive exchange coefficient for ϕ
- S - source term

Numerical Solution

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- To solve these equations they have to be converted to “finite-volume” equations.
- The FVEs connect values of the variables in individual cells.
- The FVEs are obtained by integrating the differential equation over the cell volume:

The Conservation Equation

$$\frac{\partial}{\partial t}(\rho\phi) + \nabla.(\rho\mathbf{u}\phi) = \nabla.(\Gamma\nabla\phi) + S,$$

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In each cell, we integrate over the cell volume:

$$\frac{\partial}{\partial t}\int_V \rho\phi dV + \oint_A \rho\phi\mathbf{V}\cdot d\mathbf{A} = \oint_A \Gamma\nabla\phi\cdot d\mathbf{A} + \int_V S_\phi dV$$

The Conservation Equation

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$$\frac{\partial}{\partial t}\int_V \rho\phi dV + \oint_A \rho\phi \mathbf{V}\cdot d\mathbf{A} = \oint_A \Gamma\nabla\phi\cdot d\mathbf{A} + \int_V S_\phi dV$$

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- The terms are evaluated like this:
- Transient: $(\rho_{new}\phi_{new} - \rho_{old}\phi_{old})$ * volume / Δt
- Convection: sum of (mass flow rate) * ϕ over six cell faces
- Diffusion: sum of diffusive flux over the six cell faces
- Source: (source per unit volume) * volume

Finite Volume Form

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- The FVEs can be written in this form:

$$a_P\phi_P = a_N\phi_N + a_S\phi_S + a_E\phi_E + a_W\phi_W + a_H\phi_H + a_L\phi_L + S$$

(Note: P is the cell in question – N, S, E, W etc are the neighbours.)

- Setting ϕ=1 gives the continuity equation, and so:

$$a_P = a_N + a_S + a_E + a_W + a_H + a_L$$

- and so:

$$\phi_P = \frac{(a_N\phi_N + a_S\phi_S + a_E\phi_E + a_W\phi_W + a_H\phi_H + a_L\phi_L + S)}{(a_N + a_S + a_E + a_W + a_H + a_L)}$$

- There is an equation like this to determine ϕ_P in every cell.

Finite Volume Form

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The Finite-Volume Equation determines ϕ_P in every cell.

$$\phi_P = \frac{(a_N\phi_N + a_S\phi_S + a_E\phi_E + a_W\phi_W + a_H\phi_H + a_L\phi_L + S)}{(a_N + a_S + a_E + a_W + a_H + a_L)}$$

- The a’s have the dimension of mass flow rate.
- The FVEs form a set of simultaneous equations.
- For given a’s these equations are linear, so are solved by a linear solver which inverts the matrix of coefficients.
- This happens for each ϕ on every iterative sweep.
- (Note - Advanced users only: The number of iterations LITER of the linear solver can be specified in “Iteration control”.)

The Continuity Equation

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- The mass continuity equation is obtained by setting $\phi = 1$. But then there is no equation to solve!
- Instead, we solve a “pressure-correction” equation.
- The pressure in each cell is adjusted to modify the mass flows in/out of the cell so as to achieve mass continuity.
- This determines the pressure in each cell.

The Solution Algorithm

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- The main steps in the algorithm are:
  1. Guess a pressure field.
  2. Solve the momentum equations using this pressure field, thus obtaining velocities which satisfy momentum conservation, but not mass continuity.
  3. Construct continuity errors for each cell : inflow - outflow.
  4. Solve the pressure-correction equation and adjust pressures and velocities appropriately. The velocities will now satisfy continuity, but not momentum conservation.
  5. Return to (2) and iterate.