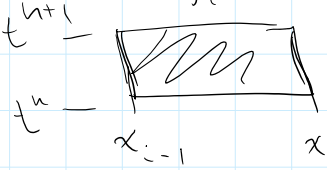


FVM to solve conservation laws  $\rightarrow$  sign comes from normal convention

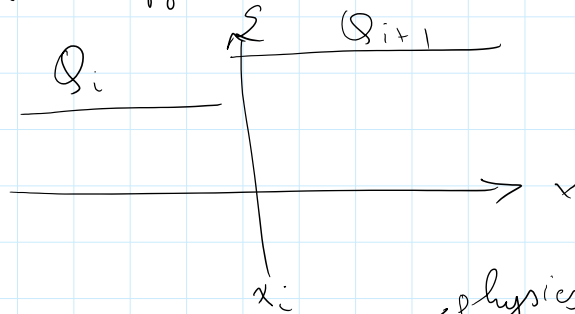
1D) General form  $q_t = - \underbrace{f(q)_x}_{\text{divergence flux}} + \underbrace{G(q)}_{\text{source term}}$

F.V. average  $Q_i^n = \frac{1}{h_i} \int_{x_{i-1}}^{x_i} q(t^n, x) dx$

update:  $Q_i^{n+1} = Q_i^n - \frac{\Delta t}{h} (F_i^n - F_{i-1}^n)$



Numerical flux: Godunov approach solve Riemann problems at each interface



Advantage of Godunov approach: separate physics (Riemann problem) and numerics (flux evaluation, Q update)

Fortran 77 | CLAWPACK  $\rightarrow$  hyperbolic PDEs

Fortran 95 | BEARCLAW (CLAWPACK descendant, elliptic/parabolic)

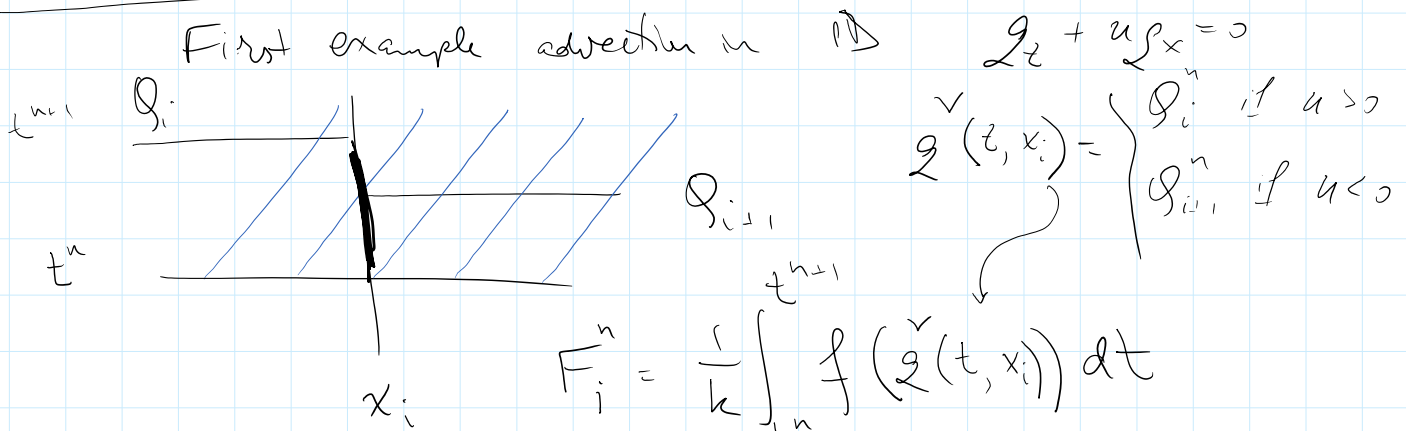
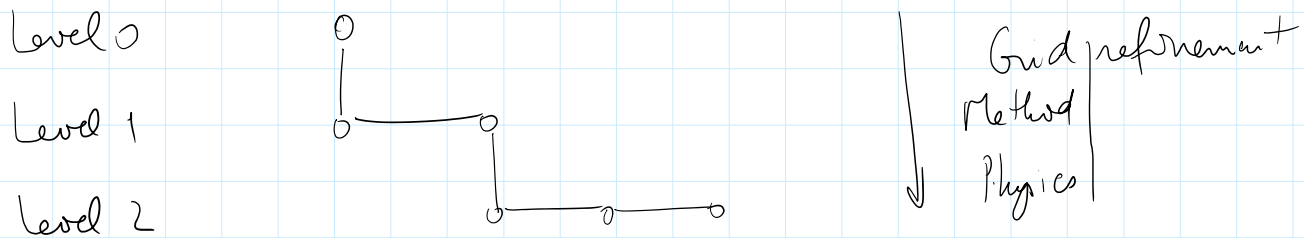
Solving the advection equation as an example of general approach

Steps:

- 0) create application directory
- 1) write problem.f90 subroutine that codes Riemann problem solution
- 2) write data files:

bear. data - general execution param  
 grid. data - define grids  
 set prob. data - problem-specific parameters

Basic BEARCLAW data: organized as a tree of Info structures



see Donald Knuth. "Literate Programming",  
 also "The Art of Computer Programming"  
 (6 volumes, ~ 600 pages)

N. Wirth: "Algorithms + Data Structures: Programs"  
 (Pascal) (~ 250p).

Basics of FORTRAN 95 (combines efficiency of FOR77,  
 with vector operations/object-oriented structures)

MODULE = an encapsulated piece that interacts with  
 program through a specified interface

problem.pro routines

setprob : read problem parameters

zinit : define initial cond.

physflux : solve Riemann problem

Info fields

Info % mX(1:4) extent of grid

Info % g(w, w, w, w, w)  
x<sub>1</sub> x<sub>2</sub> x<sub>3</sub> x<sub>4</sub> m of comp.

Info % dX mesh spacing

physflux : response to requests

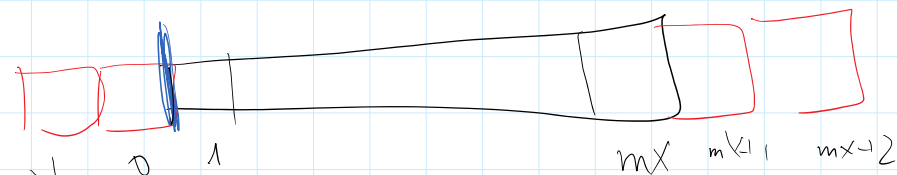
Implementation of Godunov's scheme through  
wave propagation.

LeVeque : J. Comp. Phys. 1991 paper

— " — : Finite Volume methods

Boundary conditions:

1) Ghost cells



ghost cells

pre programmed ghost cell

1 outflow  
2 periodicity  
3 solid wall

pre programmed ghost cell codes

3 solid wall  
999 internal between two grids

