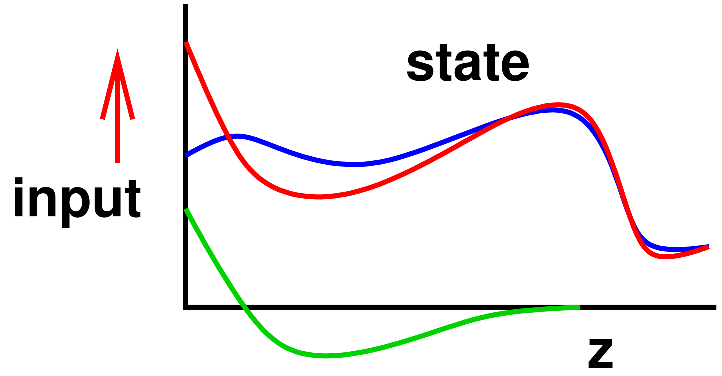
STW–TWI.6012: PACDAS 7–12–2005



systeem

PDE

zonder randwaarden: geisoleerd model

randwaarden

(interne) toestanden

zonder interne toestanden: minimaal model

port–Hamiltoniaan

Norbert Ligterink, CE–UT

optimale regeltheorie van partiele differentiaal vergelijkingen

(Optimal Control, Lions)

vind de regelaar u(z,t), voor (kost−functie: J)

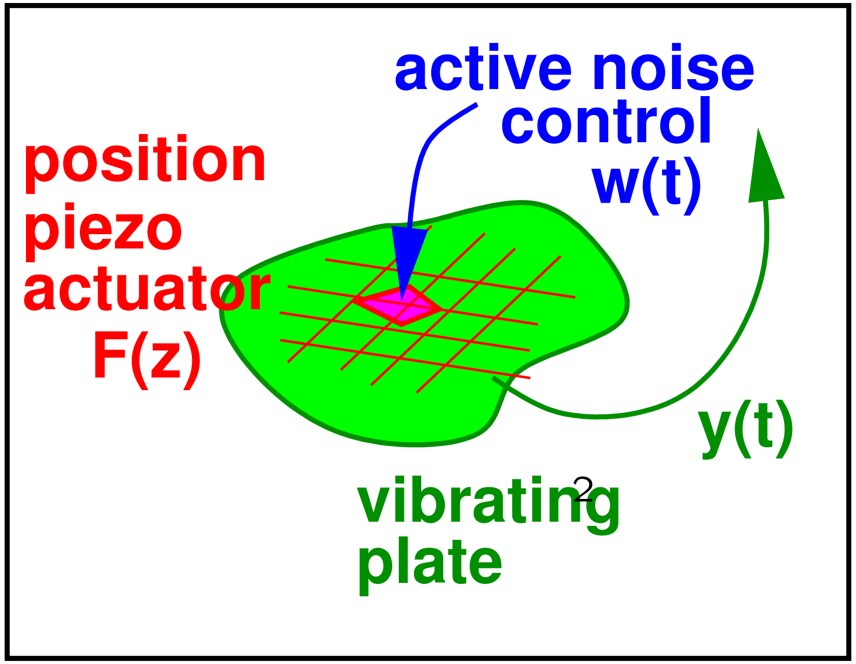
$$\min \int J(x(z,t),u(z,t))\,dz\,dt$$

In de praktijk valt de regelaar u(z,t) vaak uiteen:

$$u(z,t) = F(z)\ w(t)$$

F(z): het optimale ontwerpprobleem

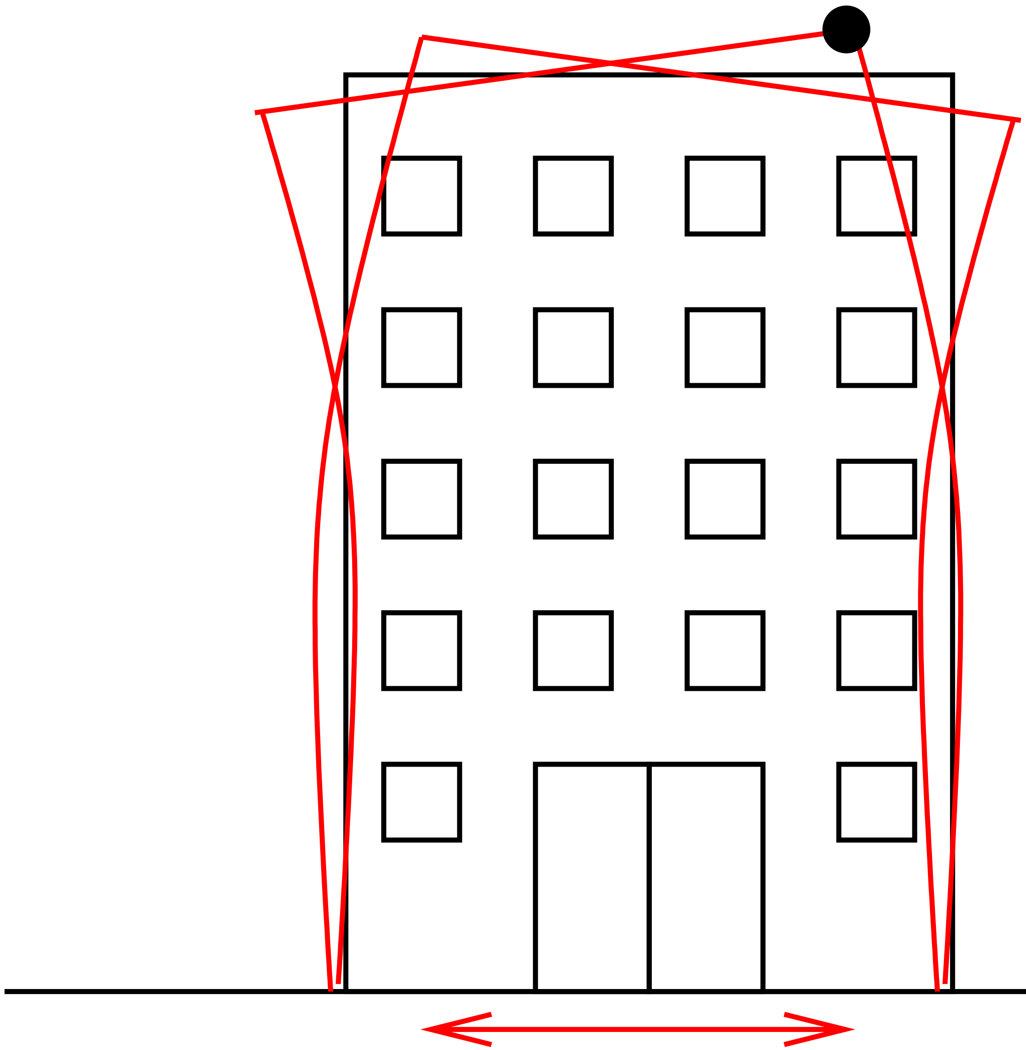
w(t): het discrete regelprobleem



"a building model"

Paul van Dooren's I/O model qualification:

sensor (output: y)



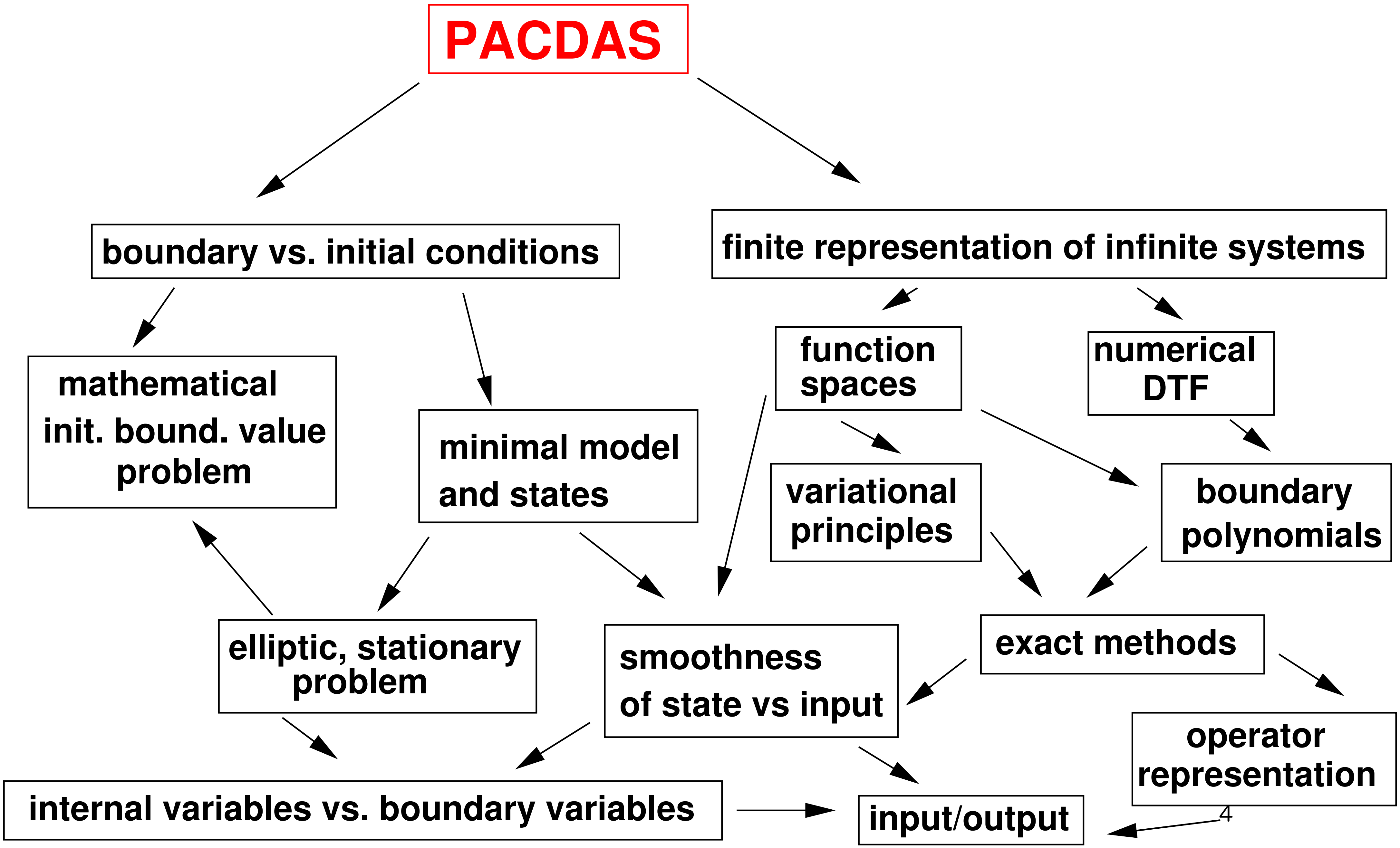
determine (transfer):

y/u (frequency)

problems:

* sensor placement?
* what is the susceptibility?
* critical parts of structure

EARTHQUAKE (input: u)


PACDAS
boundary vs. initial conditions
finite representation of infinite systems
mathematical init. bound. value problem
minimal model and states
function spaces
numerical DTF
variational principles
boundary polynomials
elliptic, stationary problem
smoothness of state vs input
exact methods
operator representation
internal variables vs. boundary variables
input/output

KALMAN is like KRYLOV

choose B, choose A

Krylov basis: start vector(s) B, matrix A

$$K_n = \{B, AB, AAB, \ldots A^n B\}$$

controllability up–side down because A is too large:

pick B, and A, such that the smallest "n" yields "most" of the dynamics:

- *motion tracking (operational modes) (B)
- *low–frequency vibrations $(A = K^{-1} M)$

The "A" of PDE: physical model = infinite system

$$\dot{x} = Ax \qquad \text{(isolated system model)}$$

normally with added input u: (applied force: Bu)

$$\dot{x} = Ax + B\,u$$

Decomposing A:

PDE:

$$A = \left[\begin{array}{c:c} A' & B \\ \hdashline C & D \end{array}\right] \left[\begin{array}{c} x' \\ \hdashline u \end{array}\right] = \left[\begin{array}{c} \dot{x}' \\ \hdashline y \end{array}\right]$$

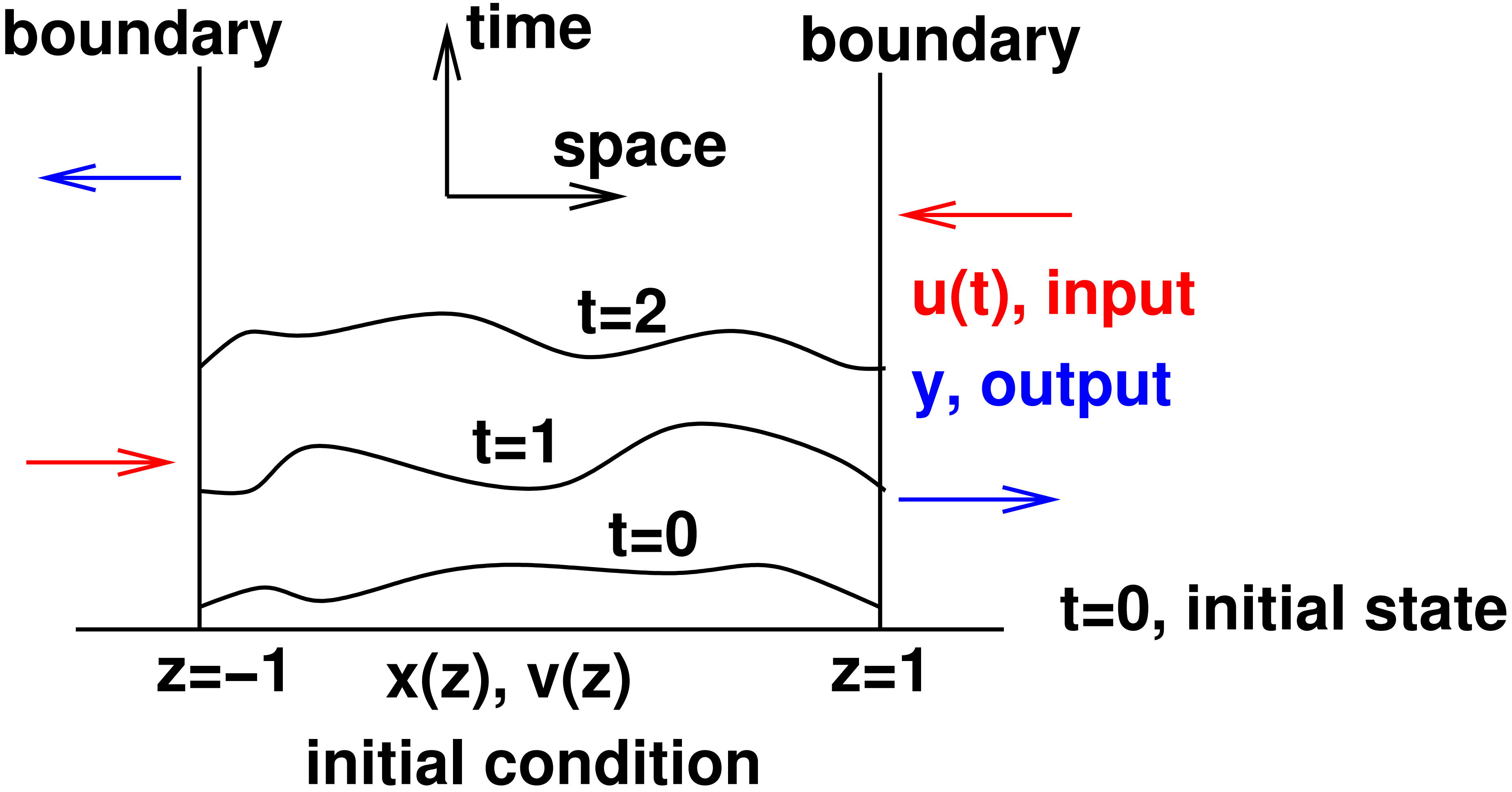
reduced state

"constraints"

minimal model

pairing (ports)

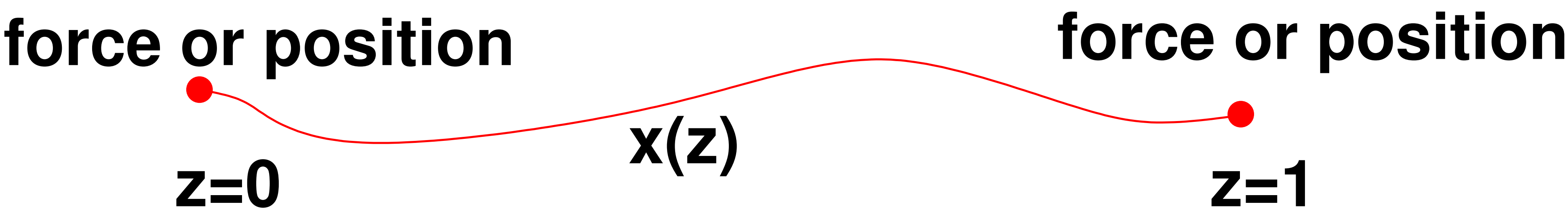
INITIAL–BOUNDARY VALUE PROBLEM



x(z,t) depends on input u, and initial state x(z,0)

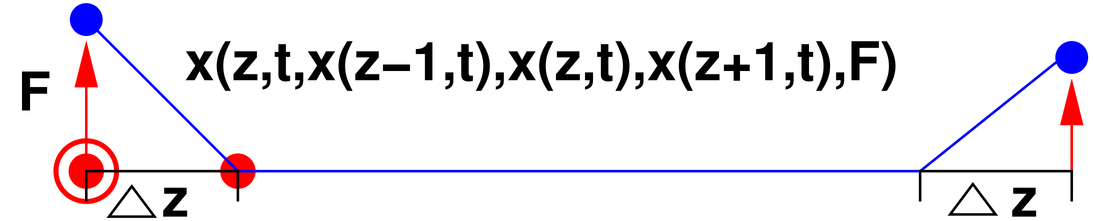
x(z,t) solution of a PDE

THE STRING AS AN EXAMPLE



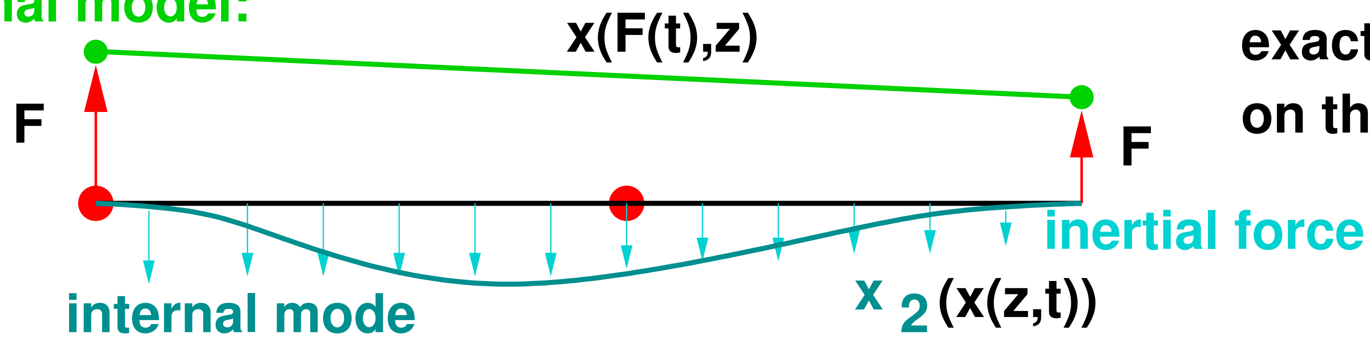
(force–force input: x(z,t) + constant, solution for any constant: free motion)

FEM solution:

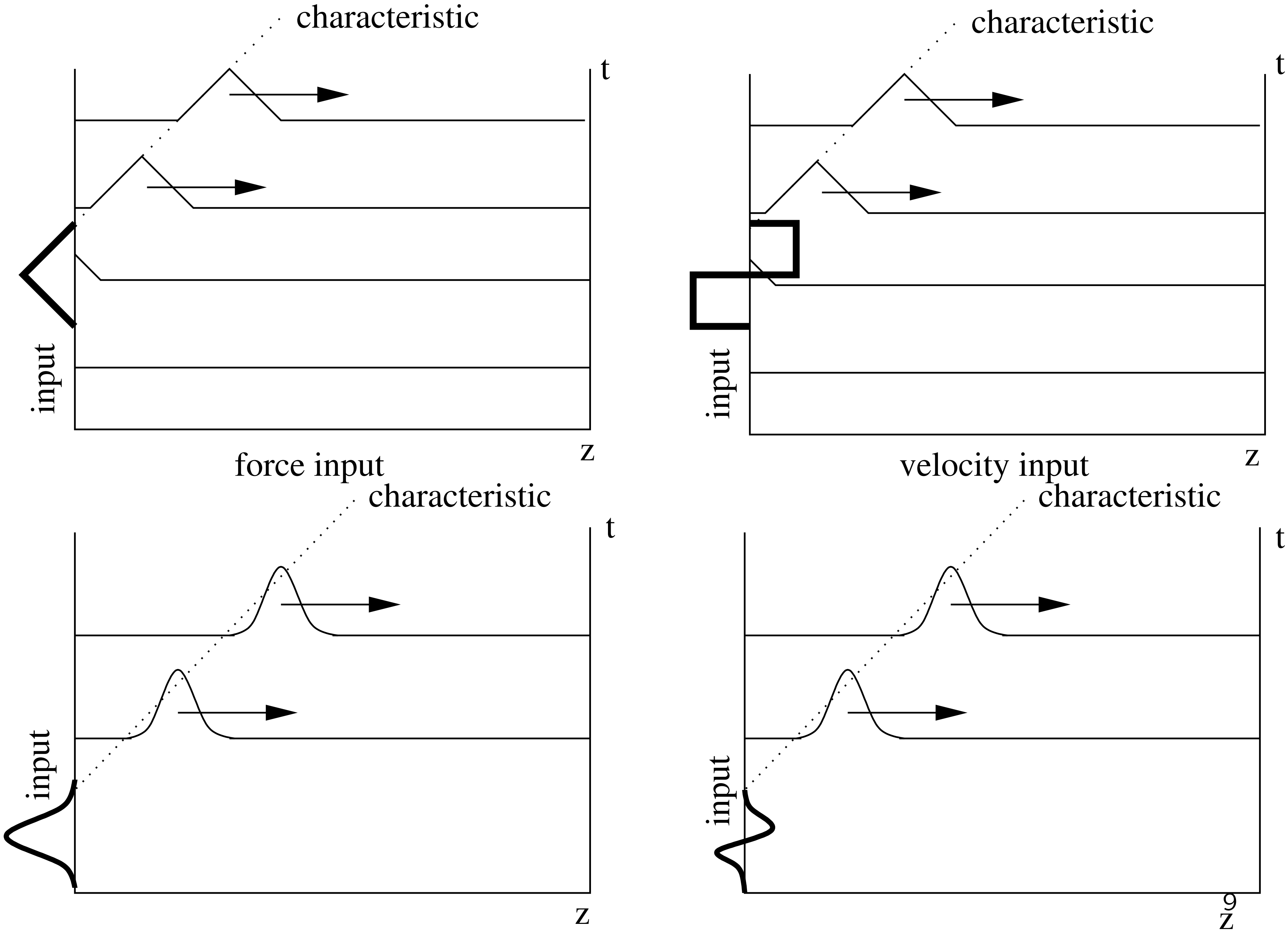


poor bounds
on the energy

Minimal model:

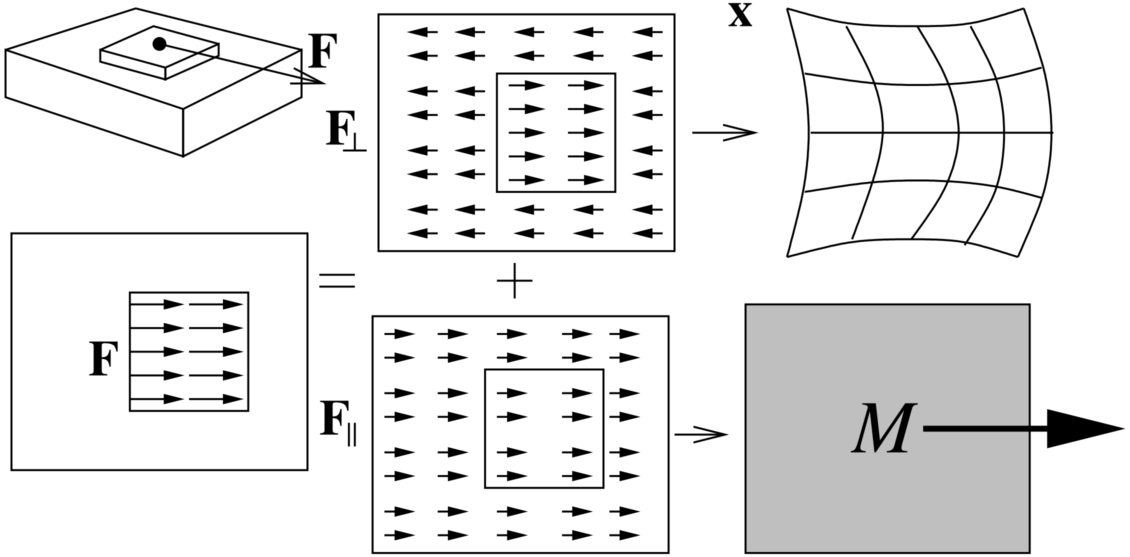


exact bounds
on the energy



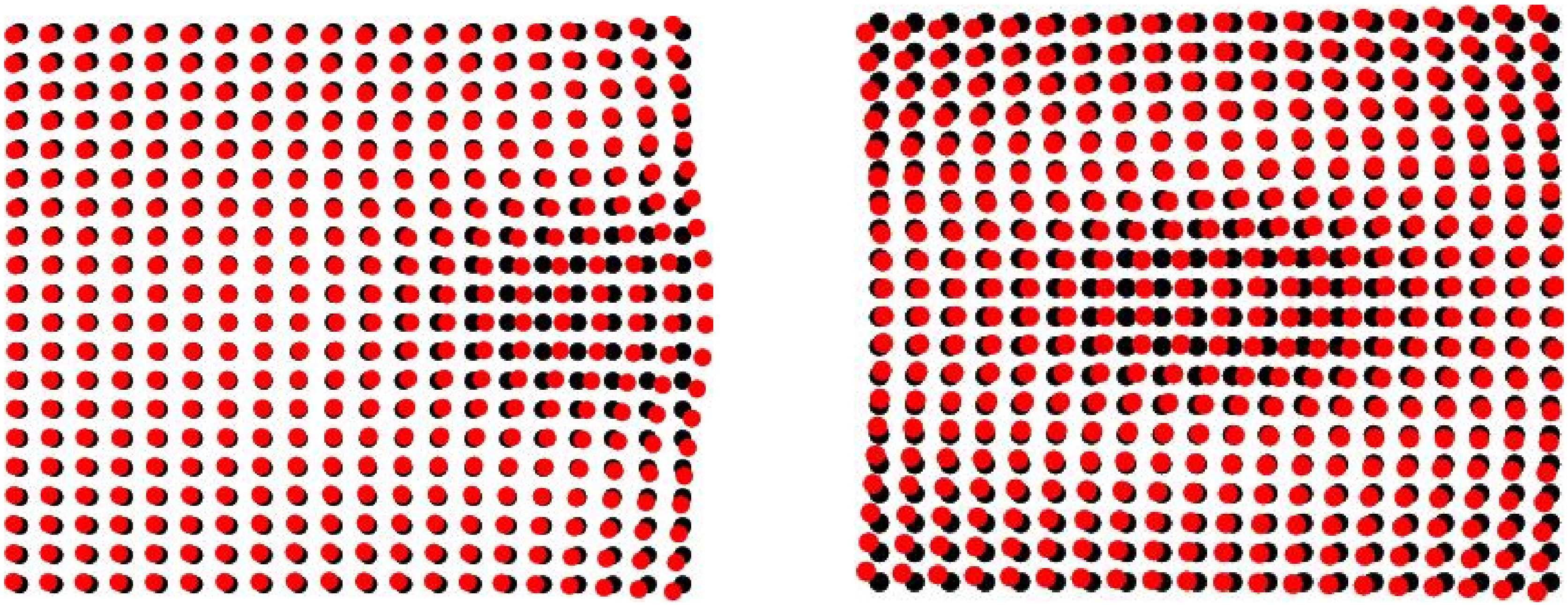
SMOOTH INPUT, SMOOTH STATE

simple wave equation



Only a limited number of functions are needed to describe the internal motion for a given applied force. However, for every fixture independently

AN EXAMPLE



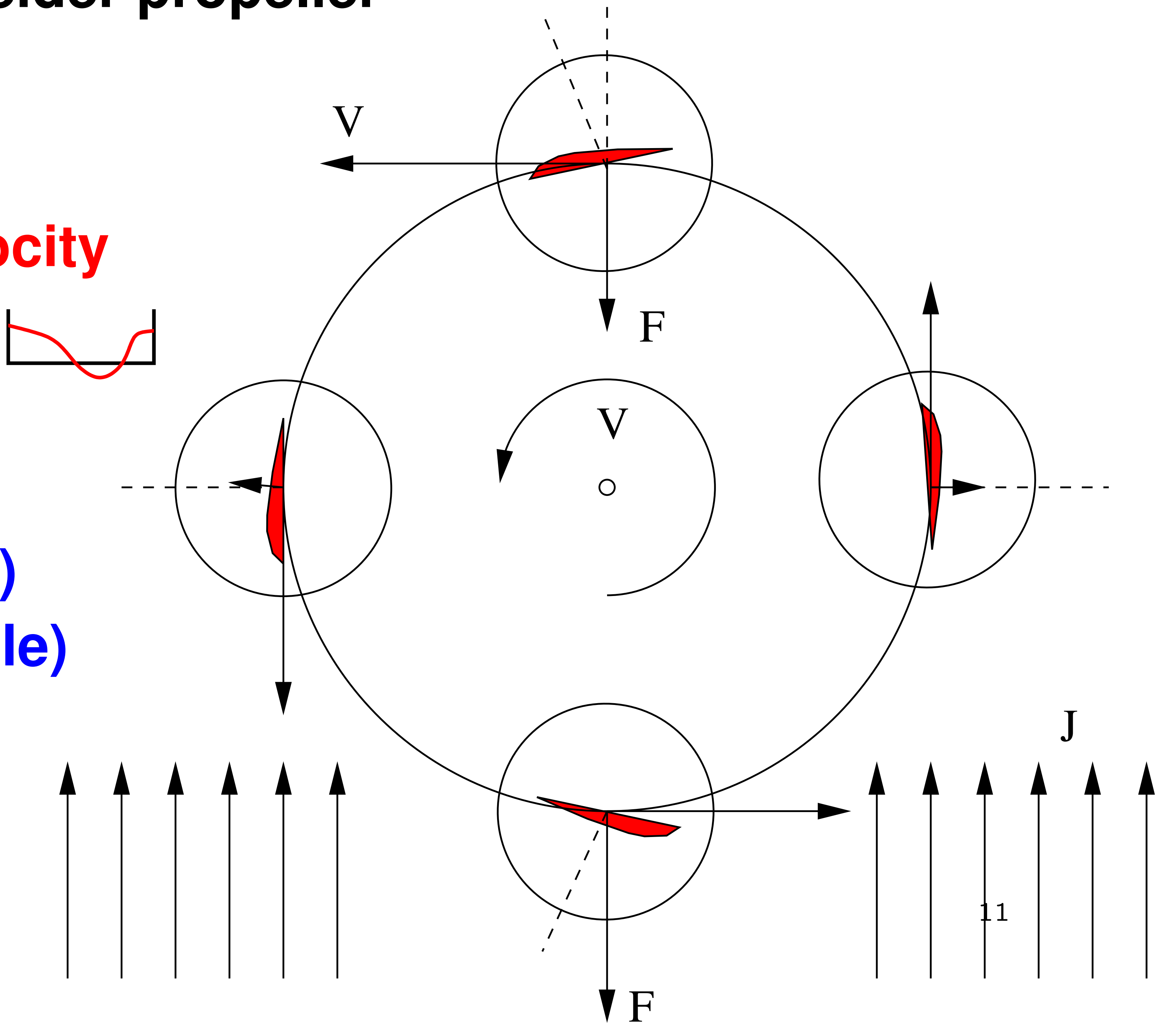
dim X = 800, dim Y = 2209

Voith–Schneider propeller

input:

rotation velocity

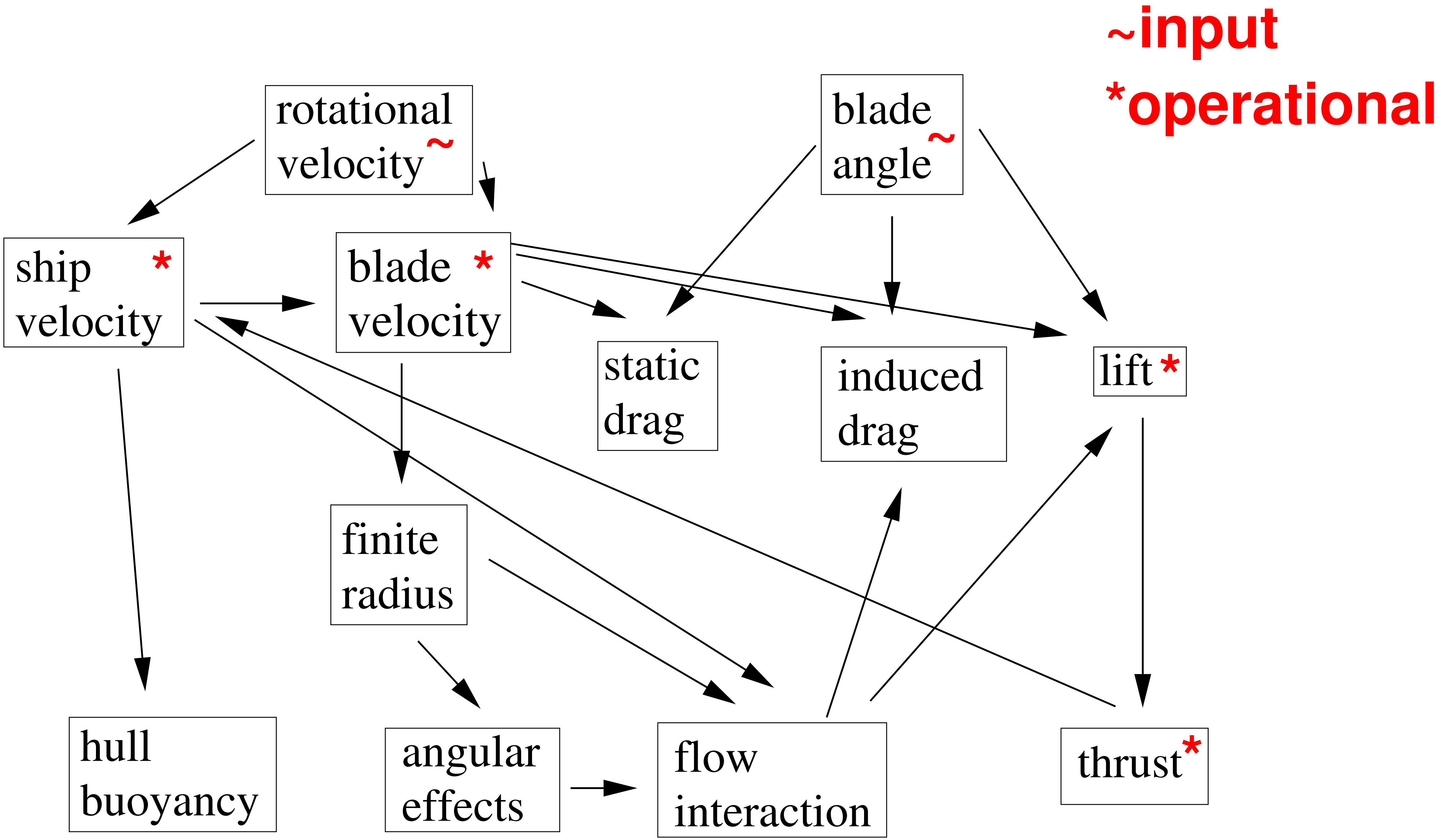
blade angle



output:

thrust(angle)

velocity(angle)



SOME MODEL HIERARCHY

for the Voith–Schneider propeller