Drasil: From generating code to generating software

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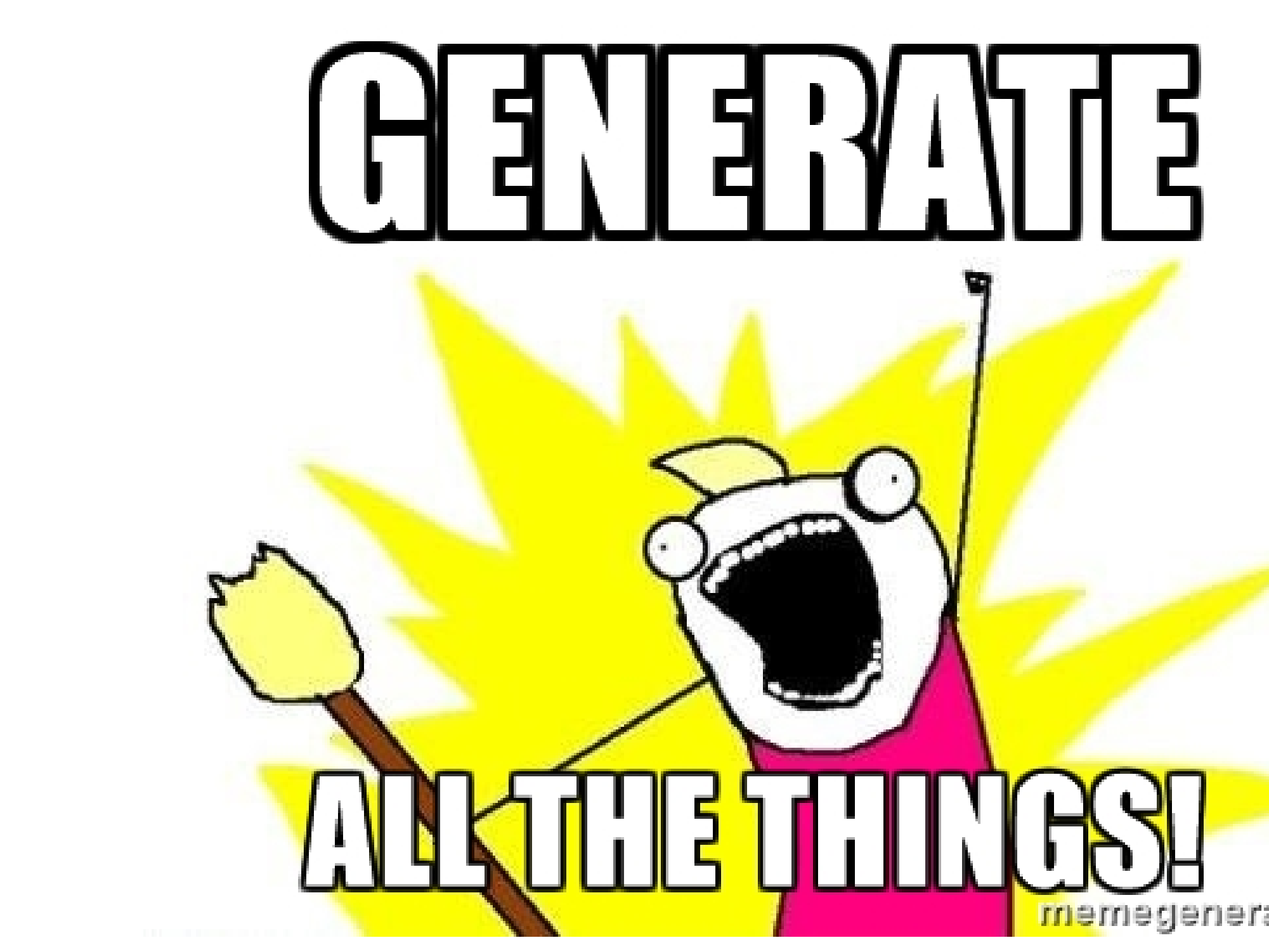
GENERATE
ALL THE THINGS!

NO

Context

software certification

Context

software (re)certification

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- All software artefacts as evidence:
  - requirements, software specification, software design, code, tests, “theory manual”, user manual, . . .

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- All software artefacts as evidence:
  - requirements, software specification, software design, code, tests, “theory manual”, user manual, . . .
- Massive amounts of knowledge duplication
  - Implies that either
    - non-code artefacts do not get maintained well enough, OR
    - are felt to be an expensive nuisance
  - duplication harms traceability

Example SRS/LP

(see document)

Literate Programming

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1. Code in most languages is not well organized for human understanding.
2. Code in some languages can not efficiently be broken down into very small pieces.
3. Chunk labels add convenient traceability information.

Drasil

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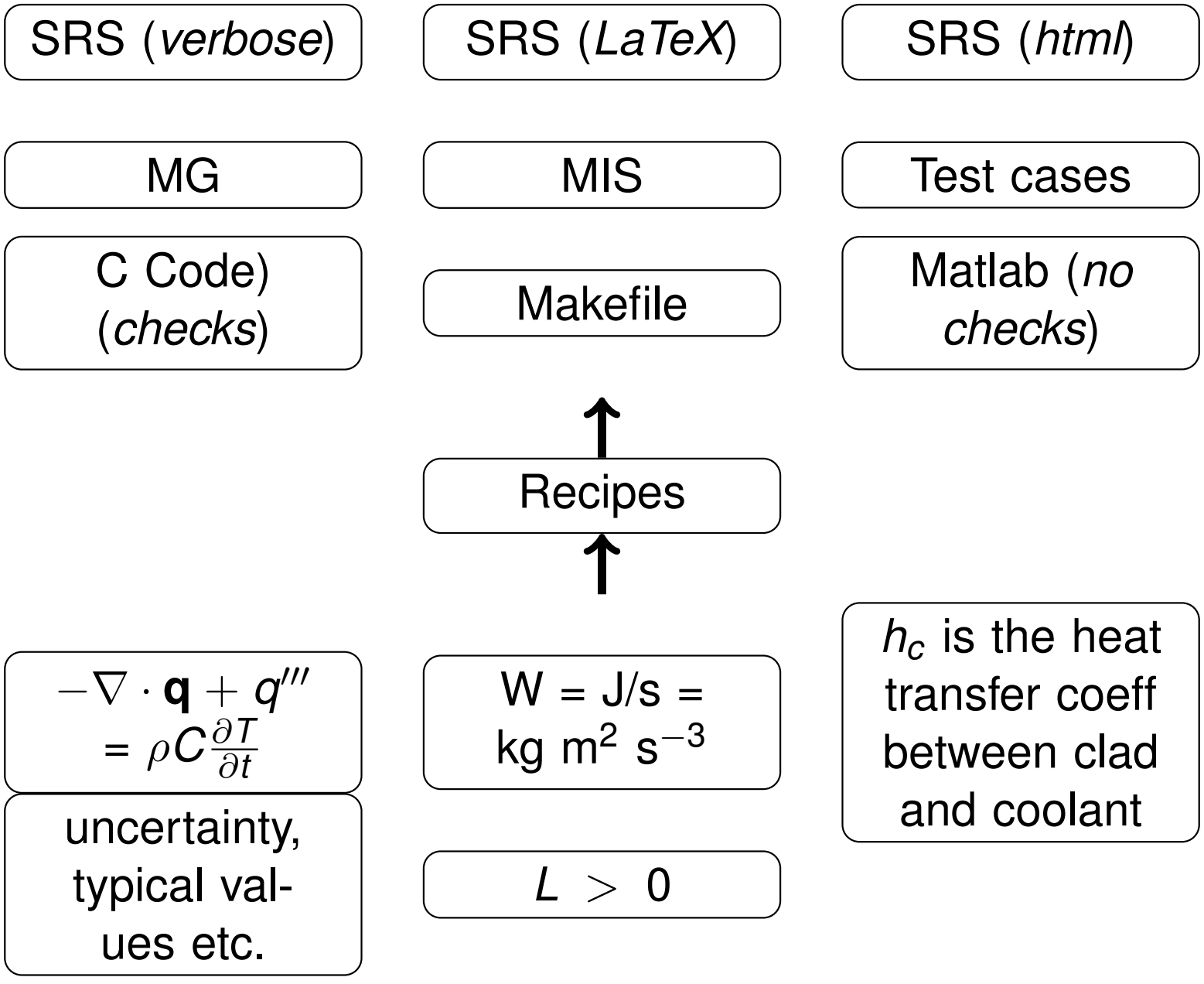
Implies:

- Bug in one place, bugs everywhere!
- Huge up-front investment.
- Doesn't work if you have no theory.

Example (high level)



Sanity checks

Var	Constraints	Typical Value	Uncertainty
L	$L > 0$	1.5 m	10%
D	$D > 0$	0.412 m	10%
V_P	$V_P > 0$	0.05 m^3	10%
A_P	$A_P > 0$	1.2 m^2	10%
ρ_P	$\rho_P > 0$	1007 kg/m^3	10%

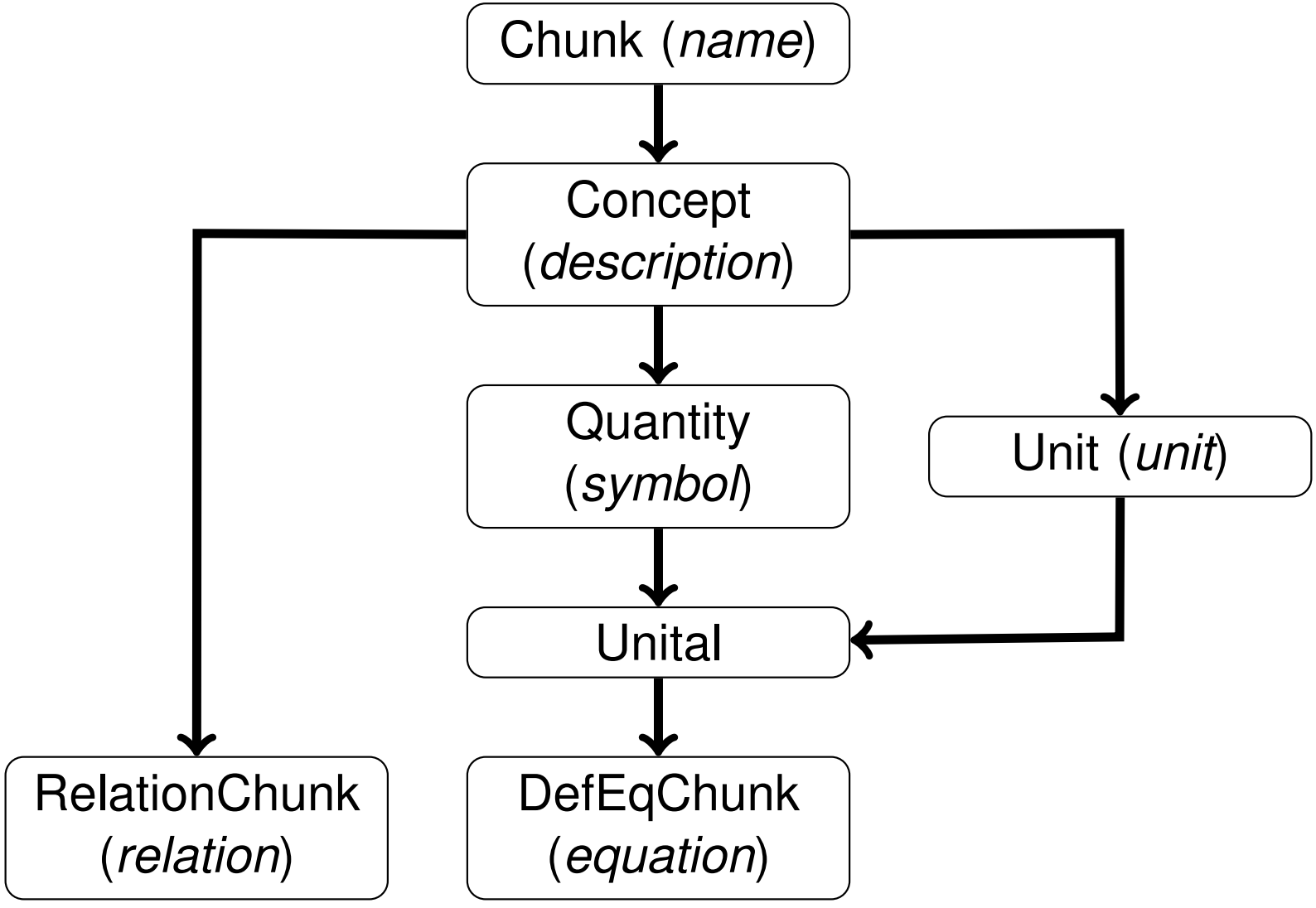
$$E_W = \int_0^t h_C A_C (T_C - T_W(t))dt - \int_0^t h_P A_P (T_W(t) - T_P(t))dt$$

- Sanity checks captured and reused
- Generate guards against invalid input
- Generate test cases

Reusability

Ref	**T1**
Label	**Conservation of energy**
Eq	$-\nabla \cdot \mathbf{q} + q''' = \rho C \frac{\partial T}{\partial t}$
Desc.	Conservation of energy for time varying heat transfer in a material of specific heat capacity C and density ρ, where $\mathbf{q}$ is the thermal flux vector, q''' is the volumetric heat generation, T is the temperature, ∇ is the del operator and t is time.

Basic Drasil Design



Example Recipe

```
vars :: [EqChunk]
vars = [h_g, h_c]

s1, s2, s3, s4 :: LayoutObj
s1=table_of_units si_units
s2=table_of_symbols vars
s3=Section 0 (S "Data Definitions") $ map (Definition.Data) vars
s4=Section 0 (S "Code") $ map (CodeBlock.toCode CLang Calc) [h_c]

srs :: Quantity s => [s] -> String -> [LayoutObj] -> Document
srs ls author body =
  Document ((S "SRS for ") :+:
    (foldr1 (:+:) (intersperse (S " and ")
    (map (\x -> U $ x ^. symbol) ls))))
    (S author) body

srsBody :: Document
srsBody = srs vars "Spencer Smith" [s1, s2, s3, s4]
```

Example Recipe

```
table_of_symbols :: (Unit s, Quantity s) => [s] -> LayoutObj
table_of_symbols ls=Section 0 (S "Table of Sym") [intro,table ls]

table :: (Unit s, Quantity s) => [s] -> LayoutObj
table ls=Table [S "Symbol",S "Description",S "Units"] (mkTable
  [(\ch -> U (ch ^. symbol)),
   (\ch -> ch ^. descr),
   (\ch -> Sy $ ch ^. unit)] ls)
  (S "Table of Symbols") False
```

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Classy Optics

```
class Chunk c where
  name :: Simple Lens c String
class Chunk c => Concept c where
  descr :: Simple Lens c Sentence
```

Units Recipe

```
fundamentals :: [FundUnit]
fundamentals = [metre, kilogram, second, kelvin, mole, ampere, candela]

derived :: [DerUChunk]
derived = [centigrade, joule, watt, calorie, kilowatt]

si_units :: [UnitDefn]
si_units = map UU fundamentals ++ map UU derived
```

Fundamental SI Units

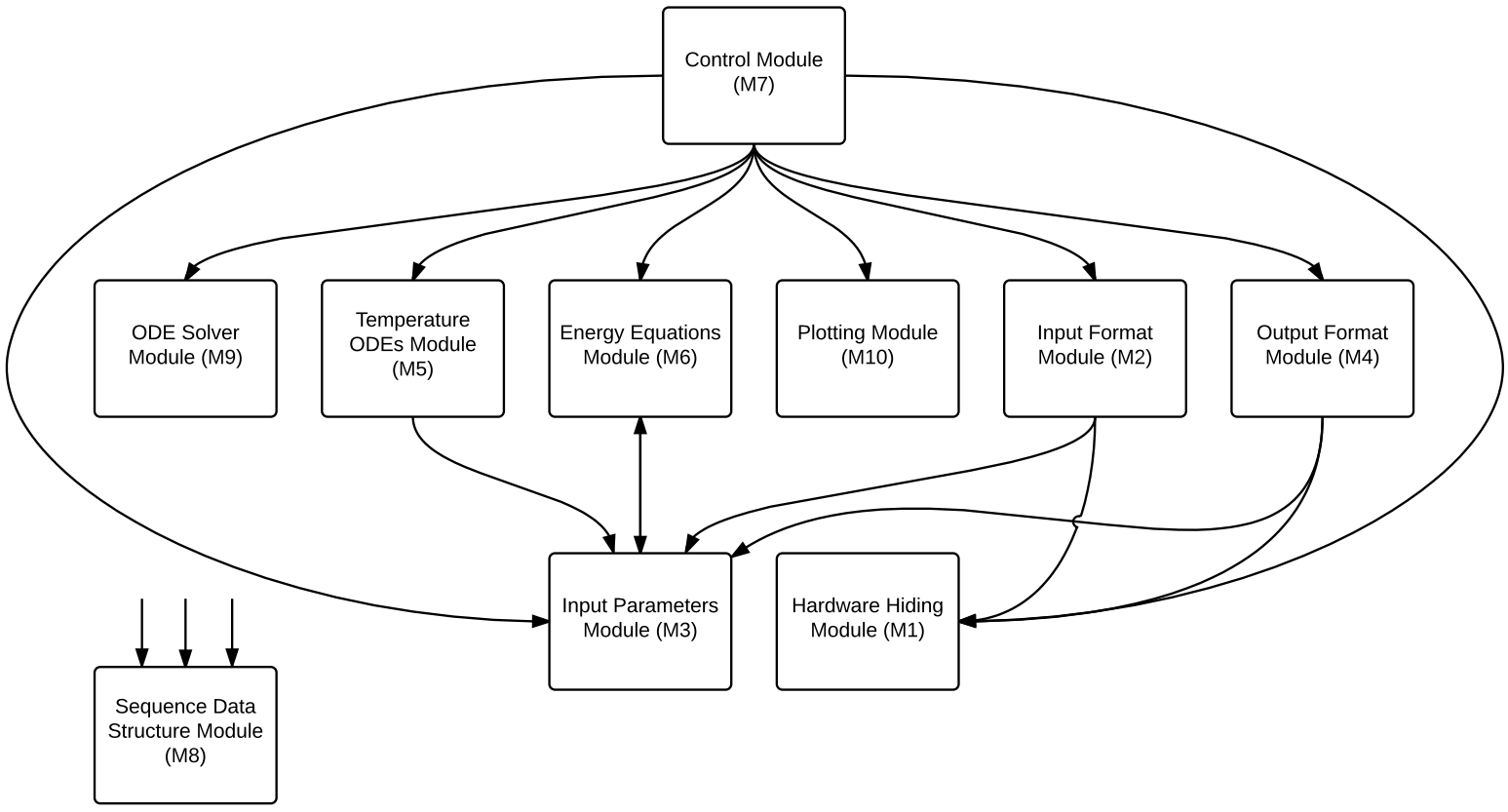
```
fund :: String -> String -> String -> FundUnit
fund nam desc sym = UD (CC nam (S desc)) (UName $ Atomic sym)

metre, kilogram, second, kelvin, mole, ampere, candela :: FundUnit
metre    = fund "Metre"    "length"              "m"
kilogram = fund "Kilogram" "mass"                "kg"
second   = fund "Second"   "time"                "s"
kelvin   = fund "Kelvin"   "temperature"         "K"
mole     = fund "Mole"     "amount of substance" "mol"
ampere   = fund "Ampere"   "electric current"    "A"
candela  = fund "Candela"  "luminous intensity"  "cd"
```

The h_c Chunk

$$h_c = \frac{2k_c h_b}{2k_c + \tau_c h_b}$$

```
heat_transfer :: DerUChunk
heat_transfer = DUC (UD ht_con ht_symb) heat_transfer_eqn

ht_con :: ConceptChunk
ht_con = makeCC "Heat transfer" "Heat transfer"

ht_symb :: USymb
ht_symb = from_udefn heat_transfer_eqn

heat_transfer_eqn = USynonym (UProd
  [kilogram ^. unit, UPow (second ^. unit) (-3),
   UPow (centigrade ^. unit) (-1)])

h_c_eq :: Expr
h_c_eq = 2*(C k_c)*(C h_b)/(2*(C k_c)+(C tau_c)*(C h_b))

h_c :: EqChunk
h_c = fromEqn "h_c" (S "convective heat transfer ...")
  (IH `sub` IC) heat_transfer h_c_eq
```

Design Documentation



Approach

- Case studies
  - Solar water heating tank
  - Slope stability analysis
  - Glass safety analysis
  - Game physics engine
  - (medium-sized industrial code)
- Small chunks of knowledge
- Aggressively look for patterns and capture
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