⍝ The Co-dfns Compiler

⍝ High-performance, Parallel APL Compiler

:Namespace CODFNS

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          ⎕IO ⎕ML ⎕WX ← 0 1 3
               VERSION ← 2017 11 0
              COMPILER ← 'vsc'
            BUILD∆PATH ← 'build'
            AF∆PREFIX ← '/usr/local'
               AF∆LIB ← 'afcuda'
VISUAL∆STUDIO∆PATH ← 'C:\Program Files (x86)\Microsoft Visual Studio\2017\Enterprise\VC\Auxiliary\Build'

 Cmp ←{_ ←{22 :: ⍬ ⋄ ω ⎕NERASE ω ⎕NTIE 0} so ← BSO α
        _ ←(⍎COMPILER) α ⊣ (BUILD∆PATH,'/', α,'_', COMPILER,'.cpp') put⍨ gc tt ⊃ a n ← ps ω
       22 :: 'COMPILE ERROR' ⎕SIGNAL 22
            n ⊣ ⎕NUNTIE so ⎕NTIE 0}
MkNS ←{NS ⊣ α∘{NS.⍎α mkf ω}¨(1 = 1 ⌷ ⍉ω)⌿ 0 ⌷ ⍉ω ⊣ NS ← #.⎕NS ⍬}
 Fix ←{α MkNS α Cmp ω}
 Xml ←{⎕XML (0 ⌷ ⍉ω),(,∘⍕⌿ 2 ↑ 1 ↓ ⍉ω),(⊂''),⍪(⊂(¯3 + ≢⍉ω) ↑ ,¨'nrsgvyel'),∘⍪¨ ↓ ⍕∘,¨ ⍉ 3 ↓ ⍉ω}
 BSO ←{BUILD∆PATH,'/', ω,'_', COMPILER, soext ⍬}
 MKA ←{mka ⊂ ω ⊣ 'mka' ⎕NA 'P  ',(BSO α),'|mkarray <PP'}
 EXA ←{exa ⍬ ω ⊣ 'exa' ⎕NA (BSO α),'|exarray >PP P'}
FREA ←{frea ω ⊣ 'frea' ⎕NA (BSO α),'|frea P'}

soext ←{'.dll' '.so' '.dylib' ⊃⍨ 'vsc' 'gcc' 'clang' ⍳ ⊂COMPILER}
  tie ←{0 :: ⎕SIGNAL ⎕EN ⋄ 22 :: ω ⎕NCREATE 0 ⋄ 0 ⎕NRESIZE ω ⎕NTIE 0}
  put ←{s ← (¯128 + 256 | 128 + 'UTF-8' ⎕UCS α) ⎕NAPPEND (t ← tie ω) 83 ⋄ 1 : r ← s ⊣ ⎕NUNTIE t}
  mkf ←{fn  ← BUILD∆PATH,'/', α,'_', COMPILER,(soext ⍬),'|',('∆' ⎕R '__' ⊢ ω),'_dwa '
        f  ← ω,'←{_←''dya''⎕NA''',fn,'>PP <PP <PP'' ⋄ '
        f ,← '_←''mon''⎕NA''',fn,'>PP P <PP'' ⋄ '
            f,'0=⎕NC''α'':mon 0 0 ω ⋄ dya 0 α ω} ⋄ 0'}
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  cio ← {' -o ''',BUILD∆PATH,'/',ω,'_',α,'.',αα,''' '}
  fls ← {'''',BUILD∆PATH,'/',ω,'_',α,'.cpp'' '}
  log ← {'> ',BUILD∆PATH,'/',ω,'_',α,'.log 2>&1'}
  lib ← {'-l',AF∆LIB,' '}
  cci ← {'-I''',AF∆PREFIX,'/include'' -L''',AF∆PREFIX,'/lib'' '}
  cco ← '-std=c++11 -Ofast -g -Wall -fPIC -shared'
  ucc ← {⎕SH αα,' ',cco,(cci ⍬),COMPILER (ωω cio,fls,lib,log) ω}
  gcc ← 'g++' ucc 'so'
clang ← 'clang++' ucc 'dylib'
 vsco ← {z ← '/W3 /wd4102 /wd4275 /Gm- /O2 /Zc:inline /Zi /Fd"',BUILD∆PATH
         z ,← '\vc.pdb" /errorReport:prompt /WX- /MD /EHsc /nologo '
              z,'/I"%AF_PATH%\include" /D "NOMINMAX" /D "AF_DEBUG" '}
 vslo ← {z ← '/link /DLL /OPT:REF /INCREMENTAL:NO /SUBSYSTEM:WINDOWS '
         z ,← '/LIBPATH:"%AF_PATH%\lib" /DYNAMICBASE "',AF∆LIB,'.lib" '
              z,'/OPT:ICF /ERRORREPORT:PROMPT /TLBID:1 '}
 vsc0 ← {'""',VISUAL∆STUDIO∆PATH,'\vcvarsall.bat" amd64'}
 vsc1 ← {' && cd "',(⊃⎕CMD'echo %CD%'),'" && cl ',(vsco ⍬),'/fast '}
 vsc2 ← {'/Fo"',BUILD∆PATH,'\\" "',BUILD∆PATH,'\',ω,'_vsc.cpp" '}
 vsc3 ← {(vslo ⍬),'/OUT:"',BUILD∆PATH,'\',ω,'_vsc.dll" '}
 vsc4 ← {'> "',BUILD∆PATH,'\',ω,'_vsc.log""'}
  vsc ← {⎕CMD ('%comspec% /C ',vsc0,vsc1,vsc2,vsc3,vsc4) ω}

  get ← {αα ⌷ ⍉ω}
 wrap ← ⍪∘(⍉ (1 + 1 ↑ ⍉) ⍪ 1 ↓ ⍉)
 bind ← {n _ e ← ω ⋄ (0 n_ ⌷ e) ← ⊂n ⋄ e}
   at ← {α ← ⊢ ⋄ A ⊣ ((,B) ⌿ (r A) ⍴ A) ← α αα (,B) ⌿ ((r ← (≢⍴ B ← ωω ω) ((×/ ↑) , ↓) ⍴) A) ⍴ (A ← ω)}

d_ t_ k_ n_ r_ s_ g_ v_ y_ e_ l_ ← ⍳ 7 + fΔ ← 4
d ← d_ get ⋄ t ← t_ get ⋄ k ← k_ get ⋄ n ← n_ get ⋄ r ← r_ get ⋄ s ← s_ get
g ← g_ get ⋄ v ← v_ get ⋄ y ← y_ get ⋄ e ← e_ get ⋄ l ← l_ get

 new ← {⍉⍪ fΔ ↑ 0 α, ω}                        ⋄ msk ← {(t ω) ∊ ⊂αα} ⋄ sel ← {(αα msk ω) ⌿ ω}
   A ← {('A' new αα) wrap ⊃⍪/ ω}                ⋄  Am ← 'A' msk        ⋄  As ← 'A' sel
   E ← {('E' new αα) wrap ⊃⍪/ ω}                ⋄  Em ← 'E' msk        ⋄  Es ← 'E' sel
   F ← {('F' new 1) wrap ⊃⍪/ (⊂ 0 fΔ ⍴ ⍬), ω}   ⋄  Fm ← 'F' msk        ⋄  Fs ← 'F' sel
   G ← {('G' new 0) wrap ⊃⍪/ ω}                 ⋄  Gm ← 'G' msk        ⋄  Gs ← 'G' sel
   L ← {('L' new 0) wrap ⊃⍪/ ω}                 ⋄  Lm ← 'L' msk        ⋄  Ls ← 'L' sel
   M ← {('M' new 0 '') wrap ⊃⍪/ (⊂ 0 fΔ ⍴ ⍬), ω} ⋄ Mm ← 'M' msk        ⋄  Ms ← 'M' sel
   N ← {'N' new 0 (⍎ω)}                         ⋄  Nm ← 'N' msk        ⋄  Ns ← 'N' sel
   O ← {('O' new αα) wrap ⊃⍪/ ω}                ⋄  Om ← 'O' msk        ⋄  Os ← 'O' sel
   P ← {'P' new 0 ω}                            ⋄  Pm ← 'P' msk        ⋄  Ps ← 'P' sel
   S ← {'S' new 0 ω}                            ⋄  Sm ← 'S' msk        ⋄  Ss ← 'S' sel
   V ← {'V' new αα ω}                           ⋄  Vm ← 'V' msk        ⋄  Vs ← 'V' sel
   Y ← {'Y' new 0 ω}                            ⋄  Ym ← 'Y' msk        ⋄  Ys ← 'Y' sel
   Z ← {'Z' new 1 ω}                            ⋄  Zm ← 'Z' msk        ⋄  Zs ← 'Z' sel
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   _o ← {0 ≥ ⊃ c a e r ← p ← α αα ω : p ⋄ 0 ≥ ⊃ c a e r2 ← p ← α ωω ω : p ⋄ c a e (r ↑⍨ - ⌊/ ≢¨ r r2)}
   _s ← {0 < ⊃ c a e r ← p ← α αα ω : p ⋄ 0 < ⊃ c2 a2 e r ← p ← e ωω r : p ⋄ (c ⌈ c2)(a, a2) e r}
_noenv ← {0 < ⊃ c a e r ← p ← α αα ω : p ⋄ c a α r}
 _env ← {0 < ⊃ c a e r ← p ← α αα ω : p ⋄ c a (e ωω a) r}
_then ← {0 < ⊃ c a e r ← p ← α αα ω : p ⋄ 0 < ⊃ c a e _ ← p ← e (ωω _s eot) a : p ⋄ c a e r}
 _not ← {0 < ⊃ c a e r ← α αα ω : 0 a α ω ⋄ 2 a α ω}
  _as ← {0 < ⊃ c a e r ← α αα ω : c a e r ⋄ c (,⊂ωω a) e r}
   _t ← {0 < ⊃ c a e r ← α αα ω : c a e r ⋄ e ωω a : c a e r ⋄ 2 θ α ω}
 _ign ← {c a e r ← α αα ω ⋄ c θ e r}
_peek ← {0 < p ← ⊃ α αα ω : p ⋄ 0 θ α ω}
 _yes ← {0 θ α ω}
 _opt ← {α(αα _o _yes)ω}
 _any ← {α(αα _s ∇ _o _yes)ω}
_some ← {α(αα _s (αα _any))ω}
 _set ← {(0 ≠ ≢ω) ∧ (⊃ω) ∊ αα : 0 (,⊃ω) α (1 ↓ ω) ⋄ 2 θ α ω}
  _tk ← {((≢,αα) ↑ ω) ≡,αα : 0 (⊂,αα) α ((≢,αα) ↓ ω) ⋄ 2 θ α ω}
 _eat ← {0 = ≢ω : 2 θ α ω ⋄ 0 (αα ↑ ω) α (αα ↓ ω)}

    ws ← (' ', ⎕UCS 9) _set
   aws ← ws _any _ign
 awslf ← (⎕UCS 10 13) _set _o ws _any _ign
  gets ← aws _s ('←' _tk) _s aws
   him ← '¯' _set
   dot ← '.' _set
   jot ← '∘' _set
  lbrc ← aws _s ('{' _set) _s aws
  rbrc ← aws _s ('}' _set) _s aws
  lpar ← aws _s ('(' _tk) _s aws _ign
  rpar ← aws _s (')' _tk) _s aws _ign
  lbrk ← aws _s ('[' _tk) _s aws _ign
  rbrk ← aws _s (']' _tk) _s aws _ign
   grd ← aws _s (':' _tk) _s aws _ign
  egrd ← aws _s ('::' _tk) _s aws _ign
 alpha ← 'ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz∆' _set
digits ← '0123456789' _set
  prim ← (prims ← '+-÷×|*⍟⌈⌊!<≤=≠≥>∧∨⍲⍱⌷?⍴,⍪⌽⊖⍉∊⍷⊃⍳○~≡≢⊢⊣/⌿\⍀⊤⊥↑↓∪∩⍋⍒∇⌹') _set
   mop ← '¨/⌿⍀\⍨' _set
  dop1 ← '.⍣∘' _set
  dop2 ←'⍤⍣∘' _set
  dop3 ←'∘' _set
   eot ← aws _s {'' ≡ ω : 0 θ α '' ⋄ 2 θ α ω} _ign
  digs ← digits _some
 odigs ← digits _any
   int ← aws _s digs _s (him _opt) _s aws
 float ← aws _s (odigs _s dot _s int _o (digs _s dot)) _s aws
  name ← aws _s (alpha _o (digits _some _s alpha) _some) _s aws
    aw ← aws _s ('αω' _set) _s aws
  aaww ← aws _s (('αα' _tk) _o ('ωω' _tk)) _s aws
   sep ← aws _s (('⋄', ⎕UCS 10 13) _set _ign) _s aws
   nss ← awslf _s (':Namespace' _tk) _s aws _s (name _opt) _s awslf _ign
   nse ← awslf _s (':EndNamespace' _tk) _s awslf _ign
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   Sfn ← aws _s (('TFF⎕' _tk) _o ('TFFI⎕' _tk)) _s aws _as {P ⌽∊ω}
  Prim ← prim _as P
    Vt ← {((0 ⎕ ⍉α) ⍳ ω) 1 ⎕ α ⍪ ⍤ ¯1}
   Var ← {α(aaww _o aw _o (name _as ⌽) _t (αα = Vt) _as (ωω V∘,∘⊃))ω}
   Num ← float _o int _as (N∘⌽)
Strand ← 0 Var 'a'  _s (0 Var 'a' _some) _as ('s' A∘⌽)
   Pex ← {α(rpar _s Ex _s lpar)ω}
  Atom ← Strand _o (0 Var 'a' _as ('v'A)) _o (Num _some _as ('n' A∘⌽)) _o Pex
   Idx ← {α(rbrk _s Ex _s lbrk _s Atom _as ('i' E∘⌽))ω}
  Blrp ← {α(αα _s (ωω Slrp ∇))ω}
  Slrp ← {α(αα _o (ωω _s ∇) _o ((1 _eat) _s ∇))ω}
    Fa ← {     e ← ('ωω' 'αα', 'αω') ,∘⍪⍤1 ⍉ ¯1 + 3 3 2 2 ⊤ (6 4 4 ⌿ 1 5 9) + 2 × ⍳ 14
               a ← e (α{ω Gex _o Ex _o Fex Stmts _then Fn⍨ αα ⍪ α})⍤2 1 ⊢ ω
               m ← (0 = 0 ⎕ ⍉a) ∧ ∧⌿ (∨⍀ ∘.=⍨ ⍳14) ∨ ∘.≢⍨ 1 ⎕ ⍉a
          ~∨⌿ m  :  (⌈⌿ 0 ⎕ ⍉a) ⍬ α ω
               z ← ('F' new 'a') wrap ⊃ (m ⌿ 'F' new¨ 1 + ⍳14) ⍪.(wrap∘⊃) m ⌿ 1 ⎕ ⍉a
                   0 (,⊂z) α ω}
    Fn ← {   ns ← n z ⌿⍨ m ← {(F_m ω) ∧ ¯1 ∊⍨ k ω} z ← ⊃⍪/ ω ⋄ 0 = ≢ns : 0 (,⊂z) α ⍤
               p ← α∘Fa¨ ns ⋄ 0 < c ← ⌈/ ⊃¨p : c ⍬ α ω
                   0 (⍪/ (⊂ 0 4 ρ ⍬) ,⍨ p {ω ((d +∘⊃ ⊣), 1 ↓⍤1 ⊢) ⊃⍪/ 1 ⊃ α}¨at{m} ↓z) α ⍤}
   Pfe ← {α(rpar _s Fex _s lpar)ω}
   Bfn ← rbrc Blrp lbrc _as ('F' new ¯1 ,∘⊂∘⌽ 1 ↓ ¯1 ↓ ⊢)
   Fnp ← Prim _o (1 Var 'f') _o Sfn _o Bfn _o Pfe
   Mop ← {α((mop _as P) _s Afx _as (1 O))ω}
  Dop1 ← {α((dop1 _as P) _s Afx _as (2 O∘⌽))ω}
  Dop2 ← {α(Atom _s (dop2 _as P) _s Afx _as (2 O∘⌽))ω}
  Dop3 ← (dop3 _as P) _s Atom _as (2 O∘⌽) _o (dot _s jot _as (P∘⌽) _as (1 O))
   Bop ← {α(rbrk _s Ex _s lbrk _s Afx _as ('i' O∘⌽))ω}
   Afx ← Mop _o (Fnp _s (Dop1 _o Dop3 _opt) _as (⊃wrap/∘⌽)) _o Dop2 _o Bop
  Bind ← {α(gets _s (name _as ⌽) _env (αα{(⊃⌽ω) αα ⍪ α}) _as (ωω new 'b', 1 ↓ ⊢))ω}
   Fex ← Afx _s (1 Bind 'F' _any) _as (⊃wrap/∘⌽)
   App ← Afx _s (Idx _o Atom _s (dop2 _not) _opt) _as {(≢ω) E ⌽ω}
    Ex ← Idx _o Atom _s {α(0 Bind 'E' _o App _s ∇ _opt)ω} _as (⊃wrap/∘⌽)
   Gex ← Ex _s grd _s Ex _as (G∘⌽)
  Nlrp ← sep _o eot Slrp (lbrc Blrp rbrc)
 Stmts ← {α(sep _any _s (Nlrp _then (αα _s eot∘⌽)) _any _s eot)ω}
    Ns ← nss Blrp nse _then (Ex _o Fex Stmts _then Fn) _s eot _as M

    ps ← {0 ≠ ⊃ c a e r ← (0 2 ρ ⍬) Ns ∊{ω /⍨ ∧\ '⍝' ≠ ω}¨ω ,¨ ⎕UCS 10 : ⎕SIGNAL c ⋄ (⊃a) e}
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 scp ← (+⍀ F_m) ⊢∘⊂⌸ ⊢
 prf ← ((≢ ↑ ¯1 ↓ ⊢ (⌿⍨) 0 ≠ ⊢)⍤1 ↑∘r) ⊢
 blg ← {α ← ⊢ ⋄ α((prf ([/ (⍳∘≢⊢) ×⍤1 (1 ↓ ⊣) ∧.(= ∨ 0 = ⊢)∘⍉ ⊢) αα (⌿∘↑) r)⌷⍤0 2 ωω (⌿⍨) αα)ω}
 enc ← ⊂ ⊣ ,∘⊃ ((⊣, '_', ⊢)/ (⊂''), (⍕¨ ⊢ (/⍨) 0 ≠ ⊢))
 veo ← ∪ ((⊂'%u'), (,¨prims), ⊣) ~⍨∘{⊃,/ {⊂⍣(1 ≡ ≡ω) ⊢ ω}¨ω} ¯1 ↓ ⊢ (/⍨) (∧/¨ 0 ≠ ((⊃ 0 ρ ⊢)¨⊢))
 ndo ← {α ← ⊢ ⋄ m ⊃∘(⊂, ⊢)¨ α∘αα¨¨ ω ⊃∘(,∘⊂⍨⊂)¨⍨ m ← 1 ≥ ≡¨ω}
 n2f ← (⊃,/) ((1 = ≡) ⊃ ,∘⊂⍨∘⊂)¨

   rn ← ⊢ ,∘↓ (1 + d) ↑⍤¯1 (+⍀ d ∘.=∘⍳ 1 + ([/ 0, d))
   rd ← ⊢ , (+/ ↑∘r ∧.(= ∨ 0 = ⊢)∘⍉∘↑∘r ⊢ (⌿⍨) F_m ∧ 1 ∊⍨ k)
   df ← ⊢ (⌿⍨) (+\ 1 = d) (~ ⊣ ∊ ⊣ (/⍨) (1 = d) ∧ (~ 'b' ∊⍨ k) ∧ O_m ∨ F_m) ⊢
  dua ← ((~G_m) ∧ F_m ∨ ↓∘prf ∊ r∘F_s) (⊣ (⍀∘⊢) (d (⌿⍨) ⊣) (0, 1 ↓ (¯1 ⌽ ⊢) ∧ ⊣ = ¯1 ⌽ ⊣) ⊣ (⌿∘⊢) 0 ∊⍨ n) ⊢
   du ← ⊢ (⌿⍨∘~) dua ∨∘(∨/) (prf ∧.(= ∨ 0 = ⊢)∘⍉ prf (⌿⍨) dua) ∧ ↑∘r ∧.≥∘⍉ dua (⌿∘⊢) ↑∘r × 0 = prf
  lfh ← (0 ≠ 1 ⌷ ⊣) ⊃ (⊂∘⍉∘⍪ 0 'M' 0 '', 0 ,⍨ (⊂⊣)) ,∘⊂∘⍉∘⍪ 1 'F' 1, ('fn' enc ⊣), (⊂⊣), 5 ↓∘, 1 ↑ ⊢
  lfn ← (d, 'Of', 3 ↓ ⊢)⍤1 at (F_m ∧ 'b' ∊⍨ k) (d, 'Vf', ('fn' enc∘⊃ r), 4 ↓ ⊢)⍤1 at (F_m ∧ 1 ∊⍨ k)
   lf ← (⊃⍪/) (1, 1 ↓ F_m ∧ 1 ∊⍨ k) blg (↑r) (⊂ lfh ⍪∘(((⊢ - (⊃ - 2 ⌊ ⊃)) d), 1 ↓⍤1 ⊢) lfn)⌸ 1 ↓ ⊢
   dn ← ((0 ∊⍨ n) ∧ (A_m ∧ 'v' ∊⍨ k) ∨ O_m ∧ 'f' ∊⍨ k) ((~⊣) (⌿∘⊢) (d - ¯1 ⌽ ⊣), 1 ↓[1] ⊢) ⊢
 mrep ← (1 + ⊃), 'P' 0 (,'⊢'), (⊂'') ,⍨ ¯1 ↓ 4 ↓∘, 1 ↑ ⊢
 mreu ← ⊃, 'E' 'u', (⊂'') ,⍨ ¯1 ↓ 3 ↓∘, 1 ↑ ⊢
  mre ← (⊃⍪/) (-∘⊃ V_m ∨ A_m)∘⊃∘⌽ (↓, (((⊢ ρ⍨ (≢⍉) ,⍨ ≢ × 2 < ≢) mreu ⍪ mrep ⍪ (1 + d), 1 ↓⍤1 ⊢)¨ ↑)) ⊢
  mrs ← ⊢ ⊂[0]⍨ 1, 1 ↓ d = 1 +∘⊃ d
  mrk ← (-∘(+/ ∧\)∘⌽ L_m) (↑ ⍪⍨∘(mre (mre mrs)¨ at (G_m∘(⊃⍪/) 1 ↑¨ ⊢)∘mrs) ↓) ⊢
   mr ← (⊃⍪/) ((1 ↑ ⊢), (mrk¨ 1 ↓ ⊢))∘scp
   ur ← ((2 ↑ ⊢), 1, ('um' enc∘⊃ r), 4 ↓ ⊢)⍤1 at (E_m ∧ 'u' ∊⍨ k)
   rt ← ⊢, (∨\ F_m) + (+⌿ prf ∧.(= ∨ 0 = ⊣)∘⍉⍨∘↑∘r M_s ⍪ G_s) - F_m
   nm ← ((3 ↑ ⊢), ('fe' enc∘⊃ r), 4 ↓ ⊢)⍤1 at ((0 ∊⍨ n) ∧ E_m ∨ O_m ∨ A_m)
  lgg ← (⍪/ 1 ↓ ⊢) ⍪∘⊃⍨ ⊣ (((¯1 + d), 2 ,⍨ t, k, n, r ,∘⍪ s) ⍪ ⊣ ⍪ 3, 'V', 'a', 3 (↓⍤1) 1 ↑ ⊢)∘⊃ 1 ↑ ⊢
   lg ← (⊃⍪/) ⊢ ((⊂ ⊣ (⌿⍨∘~) (∨\ ⊢)), (((1 ↑ ⊢) lgg ⊢ ⊂[0]⍨ d = 1 + ⊃)¨ ⊂[0]⍨)) G_m ∧ 1 ⌽ E_m
  fet ← (d, 'V' 0, 3 ↓ ⊢)⍤1 at (0, 1 ↓ E_m ∨ O_m ∨ A_m) (d, 'Av', 3 ↓ ⊢)⍤1 at (E_m ∧ 'b' ∊⍨ k)
  fee ← (⍪/⌽) (M_m ∨ E_m ∨ O_m ∨ A_m) blg ⊢ ((⊃∘⌽ ⊢) (⊂ (d - -⍨∘ ⊃), 1 ↓⍤1 ⊢)∘fet ⊣ ⍪ ¯1 ↓⍤1 ⊢)⌸ ⊃ ,⍨ 1 ↓ ⊢
   fe ← (⊃⍪/) (+⍀ d ≤ g) (⊂ (⊢ ↑⍨ 1 =∘≢ ⊢) ⍪∘⊃∘fee ⊢)⌸ ⊢
  can ← (+\ A_m ∨ O_m) ((, 1 ↑ ⊢) ,∘(⊂ (¯1 + 2 ⌊ ≢) ⊃ (⊂∘⊂ ⊃), ⊂)∘n 1 ↓ ⊢)⌸ ⊢
  cas ← (¯1 ⌽ (A_m ∨ O_m) ∧ 'vf' ∊⍨ k) ∨ (↓prf) ∊∘r ⊢ (⌿⍨) A_m ∧ 'n' ∊⍨ k
   ca ← (can ⊢ (⌿⍨) cas ∨ A_m ∨ O_m ∧ 'f' ∊⍨ k) ⊣ at (A_m ∨ O_m ∧ 'f' ∊⍨ k) ϑ ,∘⊂⍨ ⊢ (⌿⍨∘~) cas
   lj ← (⊃⍪/) (1 ↑ scp), ((⊢ ⍪ 2 'L' 0 0, 2 '' ,⍨ ¯2 ↓ 4 ↓∘, 1 ↑ ⊢)¨ 1 ↓ scp)
   sd ← (⊃⍪/) (1 ↑ scp), (n F_s) (d, 'Vf', (⊂⊣), 4 ↓ ⊢)⍤1 at ((⊂, '∇') ∊⍨ n)¨ 1 ↓ scp
  inm ← ∨⌿ ¯1 (⌽ ∨ ⊢) 1 2 (⌽ ∨ ⊢) (¯1 ¯2 ⌽ E_m ∧[1] 1 2 ∘.= k) ∧⍤1 V_m ∧ n ∊∘n F_s
  inp ← (E_m ∧ ⊣) ∨ 1, 2 ≠/ ⊣
 inza ← (1 ↑ 1 ↓ ⊣) (⌿⍨∘≢) at ((⊂, 'α') ∊⍨ n) (¯1 ↑ ⊣) (⌿⍨∘≢) at ((⊂, 'ω') ∊⍨ n) ⊢
  inz ← (1 ↑ ⊣) (d, t, k, 3 ↓⍤1 (⌿⍨∘≢)) at (0 ,⍨ 2 ≠/∘⌽ (∨\∘⌽ E_m)) inza
  inn ← (3 ↑⍤1 ⊢), ((⊣ ρ¨⍨ 1 + 0 ⌈ ([/∘n G_s)) (('fe' ≡ 2 ↑ ⊢) ⊃ (⊂⊢) ,∘⊂ 'fe', (⍕⊣), 2 ↓ ⊢)¨ n), (4 ↓⍤1 ⊢)
  ins ← ⊣ (d, t, k, ((1000 × 1 + ⊣) + 1 + n + ([/n)), 4 ↓⍤1 ⊢) at (L_m ∨ G_m) inn
  inr ← 1 ,∘⍪ ⊢ inz¨ (⍳∘≢ ⊢) ins¨ ((⊃∘n¨ ⊣) ⍳ ((⊃ n (⌿⍨) V_m ∧ 'f' ∊⍨ k)¨ ⊢)) ⊃¨ (⊂ 1 ↓¨ ⊣) ,∘⊂¨ ⊢
   in ← (⊃⍪/)∘(⊢/) (1 ↓ scp) inr∘((0 ρ ⊂ 0 8 ρ 0), ⊢/) at (⊣/) inm ((⊃¨ inp ⊂ E_m ∧ ⊣) ,∘⍪ inp ⊂[0] ⊢) ⊢
```

```
pcc ← (⊂ ⊢ (⌿⍨) A_m ∨ O_m ∧ 'f' ∊⍨ k)∘((⍳∘∪⍨ n) ⌷⍤0 2 (1 ⌈ ≢) ↑ ⊢)∘(⊃⍪⌿)∘⌽ (⌿∘⊢)
pcb ← ((, ∧.(= ∨ 0 = ⊣)∘⍪)⍤2 1⍨∘↑∘r M_s ⍪ F_s) pcc⍤1 ((⊢ (⌿⍨) (d = g) ∧ A_m ∨ E_m ∨ O_m)¨ scp)
pcv ← (d, 'V', ('af' ⊃¨∘⊂⍨ O_m), (⊃¨v), r, s, (⊂⍬) ,⍨∘⍪ g) at (O_m ∨ A_m ∧ 'v' ∊⍨ k)
pc ← (⊃⍪/) pcb {(pcv d (⊣, 1 ↓⍤1 ⊢)(α ↑⍨ 1 ⌈ ≢α) ⌷⍤0 2⍨ (n α) ⍳ n) at (V_m ∧ (n α) ∊⍨ n) ω}¨ scp
da ← ⊢ (⌿⍨∘~) (A_m ∧ d = g) ∨ (0 ,⍨ 2 ∧/ L_m) ∨ (L_m ∧ ¯1 ⌽ A_m ∧ d = g) ∨ O_m ∧ ('f' ∊⍨ k) ∧ 1 ≠ d
fce ← (⊃∘n P_s) {⊂◯ ' ω' ,⍨ (≢ω) ⊃ '' (α, '⊃') ('⊃', α, '/')} (v A_s)
fcm ← (∧/ E_m ∨ A_m ∨ P_m) ∧ 'u' ≢∘⊃∘⊃ k
fc ← ((⊃⍪/) (((d, 'An', 3 ↓ ¯1 ↓ ,) 1 ↑ ⊢), fce)¨ at (fcm¨)) ('MFOEL' ∊⍨ t) ⊂[0] ⊢
ce ← (+\ F_m ∨ G_m ∨ E_m ∨ O_m ∨ L_m) ((¯1 ↓∘, 1 ↑ ⊢) ,∘⊂ (⊃∘v 1 ↑ ⊢) ,∘(A_m ⊃¨∘↓ n ,∘⍪∘n2f v) 1 ↓ ⊢)⌸ ⊢
ll ← (⊢ (⌿⍨) 1 ⌽ L_m) (((⊂⊂'%l') ,∘⊂¨∘n ⊣) ,⍨ ¯1 ↓⍤1 ⊢) at L_m ⊢
fv ← (⊃⍪/) (((1 ↓ ⊢) ⍪⍨ (, 1 7 ↑ ⊢) ,∘⊂∘n ¯1 ↑ ⊢)¨ scp)
nvi ← ((¯1 ↓ ⊢), ({,¨ α '[' ω}/∘⊃ v))⍤1 at ((E_m ∨ O_m) ∧ 'i' ∊⍨ k)
nvv ← (⊂'%u' '%f' '%u'), (⊂ '%u' '%i', ⊢), (⊂ (⊂'%u'), ⊢)
nv ← (¯1 ↓⍤1 ((2 ↑ ⊢), 2, (3 ↓ ⊢))⍤1 at ((E_m ∨ O_m) ∧ 'i' ∊⍨ k)), ((¯1 ⊖ ≢ ⊃ nvv ,∘⊂ ⊢)¨ v∘nvi)
lt ← (⊂⍬) ,⍨ ⊢
val ← (n ⍳∘∪ n) ,¨ ⊢ (⊢ + (≢⊣) × 0 = ⊢) (⌈/ (⍳≢) ×⍤1 (∪n) ∘.((⊂⊣) ∊ ⊢) (n2f¨ v))
vag ← ∧∘~∘(∘.=⍨∘⍳ ≢)⍨ (∘.(((1 ⌷ ⊢) > 0 ⌷ ⊣) ∧ (0 ⌷ ⊢) < 1 ⌷ ⊣)⍨ val)
vae ← (∪n) (⊣ ,⍤0 ⊣ (⌷⍨⍤1 0)∘⊃ ((⊢ ,∘⊃ (⍳∘≢ ⊣) ~ ⊢ (⌿⍨) (≢⊢) ↑ ⊣)/∘⌽ (⊂⍬) ,∘↓ ⊢)) vag
vac ← (((0 ⌷∘⍉ ⊣) ⍳∘⊂ ⊢) ⊃ (1 ⌷∘⍉ ⊣) ,∘⊂ ⊢) ndo
va ← ((⊃⍪/) (1 ↑ ⊢), (((vae E_s) (d, t, k, (⊣ vac n), r, s, g, y ,∘⍪⍨ (⊂⊣) vac¨ v) ⊢)¨ 1 ↓ ⊢)) scp
avb ← {(((,¨'αω') ↑⍨ 1 ↓ ρ) ⍪ ⊢) α ⌷⍨⍤2 0 ⊢ αα ⍳ αα ∩⍨ (↓ (⌽ 1 +∘⍳ 0 ⍳⍨ ⊢) ((≢⊢) ↑ ↑)⍤0 1 ⊢) ⊃ r ω}
avi ← ¯1 0 + (ρ⊣) ⊤ (,⊣) ⍳ (⊂⊢)
avh ← {⊂ ω, (nω) ((αα (ωω avb) ω) {αα avi ndo (⊂α), ω})¨ v ω}
av ← (⊃⍪/) (+\ F_m) {α((α ((∪∘⌽ (0 ρ ⊂''), n) E_s)⌸ ω) avh (r (1 ↑ ω) ⍪ F_s ω))⌸ ω} ⊢
rlf ← (⌽ ↓ (((1 ⊃ ⊣) ∪ ⊢ ~ 0 ⌷ ⊣)/∘⌽ (⊂⍬), ↑)⍤0 1⍨ 1 +∘⍳ ≢) (⊖ 1 ⊖ n ,⍤0 (⊂⊣) veo¨ v)
rl ← ⊢ ,∘(⊃,/) (⊂∘n O_s ⍪ F_s) rlf¨ scp
vc ← (⊃⍪/) (((1 ↓ ⊢) ⍪⍨ (1 7 ↑ ⊢), (≢∘∪∘n E_s), 1 ¯3 ↑ ⊢)¨ scp)
eff ← (⊃⍪/) ⊢ (((⊂∘⍉∘⍪ d, 'Fe', 3 ↓ ,) 1 ↑ ⊣), 1 ↓ ⊢) (d =∘⊃ d) ⊂[0] ⊢
ef ← (F_m ∧ ¯1 =∘×∘⊃¨ y) ((⊃⍪/) (⊂ ⊢ (⌿⍨)∘~ (∨\ ⊣)), (eff¨ ⊂[0])) ⊢
ifn ← 1 'F' 0 'Init' ⍬ 0 1, (4 ρ 0) ⍬ ⍬ ,⍨ ⊢
if ← (1 ↑ ⊢) ⍪ (⊢ (⌿⍨) O_m ∧ 1 = d) ⍪ ((⊢ wrap⍨∘ifn∘≢∘∪ n) ⊢ (⌿⍨) E_m ∧ 1 = d) ⍪ (∨\ F_m) (⌿∘⊢) ⊢
fgz ← (1 ↑ ⊢) ⍪ (((¯1 + d), 1 ↓⍤1 ⊢) 1 ↓ ⊢) ⍪ 2, 'G', 1, 3 ↓⍤1 (¯1 ↑ ¯1 ↓⍤1 ⊢) ,∘n 1 ↑ ⊢
fg ← (⊃⍪/) (fgz¨ at (G_m∘(⊃⍪/) 1 ↑¨ ⊢) ⊢ ⊂[0]⍨ d = 2 ⌊ g)
fft ← (, 1 ↑ ⊢) (1 'Z', (2 ↓ ¯5 ↓ ⊣), (v⊣), n, y, (⊂ 2 ↑∘,∘⊃∘⊃ e), l) (¯1 ↑ E_s)
ff ← ((⊃⍪/) (1 ↑ ⊢), (((1 ↑ ⊢) ⍪ (((¯1 + d), 1 ↓⍤1 ⊢) 1 ↓ ⊢) ⍪ fft)¨ 1 ↓ ⊢)) scp
fzh ← ((∪n) ∩ (⊃∘l ⊣)) (¯1 ⌽ (⊂⊣), ((≢⊢) - 1 + (⌽n) ⍳ ⊣) ((⊂ ⊣ ⊃¨∘⊂ (⊃¨e)), (⊂ ⊣ ⊃¨∘⊂ (⊃¨y)) ,∘⊂ ⊣) ⊢) ⊢
fzf ← 0 ≠ (≢∘ρ¨∘⊃∘v ⊣)
fzb ← (((⊃∘v ⊣) (⌿⍨) fzf), n) ,∘⍪ ('f'∘,∘⍕¨∘⍳ (+/fzf)), ('s'∘,∘⍕¨∘⍳∘≢ ⊢)
fzv ← ((⊂⊣) (⊖↑)⍨¨ (≢⊣) (- +∘⍳ ⊢) (≢⊢)) ((⊢ ,⍨ 1 ⌷∘⍉ ⊣) ⌷⍨ (0 ⌷∘⍉ ⊣) ⍳ ⊢)⍤2 0¨ v
fze ← (¯1 + d), t, k, fzb ((⊢/ (-∘≢ ⊢) ↑ ⊣), r, s, g, fzv, y, e ,∘⍪ l) ⊢
fzs ← (, 1 ↑ ⊢) (1 ⊖ (⊣ ((1 'Y', (2 ⌷ ⊣), ⊢) ⍪∘⍉∘⍪ (3 ↑ ⊣), ⊢) 1 ⌽ fzh, ¯1 ↓ 6 ↓ ⊣) ⍪ fze) (⌿∘⊢)
fz ← ((⊃⍪/) (1 ↑ ⊢), (((2 = d) (fzs ⍪ (1 ↓∘~ ⊣) (⌿∘⊢) 1 ↓ ⊢) ⊢)¨ 1 ↓ ⊢)) (1, 1 ↓ S_m) ⊂[0] ⊢
fd ← (1 ↑ ⊢) ⍪ ((1, 'Fd', 3 ↓ ⊢)⍤1 F_s) ⍪ 1 ↓ ⊢

tta ← (fc∘da∘(pc⍣≡)∘mr⍣≡)∘in⍣3∘sd∘lj∘ca∘fe∘lg∘nm∘rt∘mr∘dn∘lf∘du∘df∘rd∘rn
tt ← fd∘fz∘ff∘fg∘if∘ef∘vc∘rl∘av∘va∘lt∘nv∘fv∘ll∘ce∘ur∘tta
```

```
 E1 ← {'fn' gcl ((⊂ n ,∘⊃ v), e, y) ω}
 E2 ← {'fn' gcl ((⊂ n ,∘⊃ v), e, y) ω}
 E0 ← {r l f ← ⊃ v ω ⋄ (n ω) ((⊃ y ω) sget) (¯1 ↓ ⊃ y ω) (f scal sdb) r l}
 O1 ← {'op' gcl ((⊂ n ,∘⊃ v), e, y) ω}
 O2 ← {'op' gcl ((⊂ n ,∘⊃ v), e, y) ω}
 O0 ← {''}
 Of ← {'EF(', ('∆' ⎕R '__' ⊃ n ω), ',', (⊃⊃ v ω), ');', nl}
 Fd ← {'FP(', (⊃ n ω), ');', nl}
 F0 ← {'DF(', (⊃ n ω), '_f){', nl, 'A*env[]={tenv};', nl}
 F1 ← {'DF(', (⊃ n ω), '_f){', nl, ('env0' dnv ω), (fnv ω)}
 G0 ← {v ← (⊃⊃ v ω) ('' var) 1 ⊃ ⊃ e ω
          'if(1!=cnt(', v, '))err(5);if(', v, '.v.as(s32).scalar<I>()){', nl}
 G1 ← {'z=', ((⊃ n ω) ('' var) ⊃ ⊃ e ω), ';goto L', (⍕⊃ l ω), ';}', nl}
 L0 ← {'z=', a, ';L', (⍕⊃ n ω), ':', (a ← (1 ⊃ ⊃ v ω) ('' var) 1 ⊃ ⊃ e ω), '=z;', nl}
 Z0 ← {'}', nl, nl}
 Z1 ← {'}', nl, nl}
 Ze ← {'}', nl, nl}
 M0 ← {rth, ('tenv' dnv ω), nl, 'A*env[]={', ((0 ≡ ⊃ω) ⊃ 'tenv' 'NULL'), '};', nl, nl}
 S0 ← {(('{', rk0, srk, 'DO(i,prk)cnt*=sp[i];', spp, sfv, slp) ω)}
 Y0 ← {⊃,/ ((⍳ ≢ ⊃ n ω) ((⊣ sts¨ (⊃l) ,¨∘⊃ s), '}', nl, ⊣ ste¨ (⊃n) var¨∘⊃ r) ω), '}', nl}

gc ← {⊃,/ {0 = ⊃ t ω : ⊂ 5 ⍴ ⍬ ⋄ ⊂ (⍎ (⊃ t ω), ⍕ ⊃ k ω) ω}⍤1 ⊢ ω}

 syms  ← ,¨ '+'     '-'     '×'     '÷'     '*'     '⍟'     '|'     '○'     '⌊'     '⌈'     '!'
 nams  ←    'add'   'sub'   'mul'   'div'   'exp'   'log'   'res'   'cir'   'min'   'max'   'fac'
 syms ,← ,¨ '<'     '≤'     '='     '≥'     '>'     '≠'     '~'     '∧'     '∨'     '⍲'     '⍱'
 nams ,←    'lth'   'lte'   'eql'   'gte'   'gth'   'neq'   'not'   'and'   'lor'   'nan'   'nor'
 syms ,← ,¨ '⌷'     '['     '⍳'     '⍴'     ','     '⍪'     '⌽'     '⍉'     '⊖'     '∊'     '⊃'
 nams ,←    'sqd'   'brk'   'iot'   'rho'   'cat'   'ctf'   'rot'   'trn'   'rtf'   'mem'   'dis'
 syms ,← ,¨ '≡'     '≢'     '⊢'     '⊣'     '⊤'     '⊥'     '/'     '⌿'     '\'     '⍀'     '?'
 nams ,←    'eqv'   'nqv'   'rgt'   'lft'   'enc'   'dec'   'red'   'rdf'   'scn'   'scf'   'rol'
 syms ,← ,¨ '↑'     '↓'     '¨'     '⍨'     '.'     '⍤'     '⍣'     '∘'     '∪'     '∩'
 nams ,←    'tke'   'drp'   'map'   'com'   'dot'   'rnk'   'pow'   'jot'   'unq'   'int'
 syms ,← ,¨ '⍋'     '⍒'     '∘.'    '⍷'     '⊂'     '⌹'     '⎕FFT'  '⎕IFFT' '%u'
 nams ,←    'gdu'   'gdd'   'oup'   'fnd'   'par'   'mdv'   'fft'   'ift'   ''

   nl ← ⎕UCS 13 10 ⋄ fvs ← ,⍤0 (⌿⍨) 0 ≠ (≢∘⍴¨ ⊣) ⋄ cln ← '¯' ⎕R '-' ⋄ cnm ← (syms ⍳ ⊂) ⊃ (nams, ⊂)
 lits ← {'A(0,eshp,constant(', (cln ⍕ ω), ',eshp,', ('f64' 's32' ⊃⍨ ω = ⌊ω), '))'}
 litv ← {'std::vector<', ('DI' ⊃⍨ ∧/ ω = ⌊ω), '>{', (cln ⊃ {α, ',', ω}/ ⍕¨ ω), '}.data()'}
 lita ← {'A(1,dim4(', (⍕≢ω), '),array(', (⍕≢ω), ',', (litv ω), '))'}
  lit ← {' ' = ⊃ 0 ⍴ ω : (cnm ω), α ⋄ 1 = ≢ω : lits ω ⋄ lita ω}
  var ← {α ≡ ,'⍺' : ,'l' ⋄ α ≡ ,'⍵' : ,'r' ⋄ ¯1 ≥ ⊃ω : αα lit ,α ⋄ 'env[', (⍕⊃ω), '][', (⍕⊃ ⌽ω), ']'}
  dnv ← {(0 ≡ z) ⊃ ('A ', α, '[', (⍕ z ← ⊃ v ω), '];') ('A*', α, '=NULL;')}
  fnv ← {z ← 'A*env[', (⍕ 1 + ⊃ s ω), ']={', (⊃,/ (⊂'env0'), {',p[', (⍕ω), ']'}¨ ⍳ ⊃ s ω), '};', nl}
  gcl ← {z r l n ← ((3 ⍴ ⊂'fn'), ⊂α) {⊃ α var/ ω}¨ ↓ (⊃ω), ⍪ 1 ⊃ ω ⋄ n, '(', (⊃{α, ',', ω}/ z l r ~ ⊂'fn'), ',env);', nl}
```

```
∇Z ← Gfx∆Init S
  'w_new'   ⎕NA 'P  ', (BSO S), '|w_new <C[]'
  'w_close' ⎕NA 'I  ', (BSO S),'|w_close P'
  'w_del'   ⎕NA (BSO S), '|w_del P'
  'w_img'   ⎕NA (BSO S), '|w_img <PP P'
  'w_plot'  ⎕NA (BSO S), '|w_plot <PP P'
  'w_hist'  ⎕NA (BSO S), '|w_hist <PP F8 F8 P'
  'loadimg' ⎕NA (BSO S), '|loadimg >PP <C[] I'
  'saveimg' ⎕NA (BSO S), '|saveimg <PP <C[]'
  Z ← 0 0 ρ θ
∇

    Display ← {α ← 'Co-dfns' ⋄ W ← w_new ⊂α ⋄ 777 :: w_del W
                          w_del W ⊣ W αα{w_close α : ⍎'⎕SIGNAL 777' ⋄ α αα ω}⍣ωω ⊢ ω}
LoadImage ← {α ← 1 ⋄ ⍉ loadimg θ ω α}
SaveImage ← {α ← 'image.png' ⋄ saveimg (⍉ω) α}
      Image ← {~ 2 3 ∨.= ≢ρω : ⎕SIGNAL 4 ⋄ (3 ≠ 2 ⊃ 3 ↑ ρω) ∧ 3 = ≢ρω : ⎕SIGNAL 5 ⋄ ω ⊣ w_img (⍉ω) α}
        Plot ← {~ 2 ≠ ≢ρω : ⎕SIGNAL 4 ⋄ ~ 2 3 ∨.= 1 ⊃ ρω : ⎕SIGNAL 5 ⋄ ω ⊣ w_plot ω α}
 Histogram ← {ω ⊣ w_hist ω, α}
```

:EndNamespace