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⍝ The Co-dfns Compiler
⍝ High-performance, Parallel APL Compiler
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:Namespace CODFNS

                ⎕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 '}
 vsc_0 ← {'""', VISUAL∆STUDIO∆PATH, '\vcvarsall.bat" amd64'}
 vsc_1 ← {' && cd "', (⊃⎕CMD 'echo %CD%'), '" && cl ', (vsco ⍬), '/fast '}
 vsc_2 ← {'/Fo"', BUILD∆PATH, '\\" "', BUILD∆PATH, '\', ω, '_vsc.cpp" '}
 vsc_3 ← {(vslo ⍬), '/OUT:"', BUILD∆PATH, '\', ω, '_vsc.dll" '}
 vsc_4 ← {'> "', BUILD∆PATH, '\', ω, '_vsc.log""'}
   vsc ← {⎕CMD ('%comspec% /C ', vsc_0, vsc_1, vsc_2, vsc_3, vsc_4) ω}

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

d_ t_ k_ n_ r_ s_ g_ v_ y_ e_ l_ ← ι 7 + f∆ ← 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 ← {⍉⍪ f∆ ↑ 0 α, ω}                           ⋄ msk ← {(t ω) ∊ ⊂αα} ⋄ sel ← {(αα msk ω) ⌿ ω}
    A ← {('A' new αα) wrap ⊃⍪/ ω}                   ⋄ A_m ← 'A' msk      ⋄ A_s ← 'A' sel
    E ← {('E' new αα) wrap ⊃⍪/ ω}                   ⋄ E_m ← 'E' msk      ⋄ E_s ← 'E' sel
    F ← {('F' new αα) wrap ⊃⍪/ (⊂ 0 f∆ ρ ⍬), ω}     ⋄ F_m ← 'F' msk      ⋄ F_s ← 'F' sel
    G ← {('G' new 0) wrap ⊃⍪/ ω}                    ⋄ G_m ← 'G' msk      ⋄ G_s ← 'G' sel
    L ← {('L' new 0) wrap ⊃⍪/ ω}                    ⋄ L_m ← 'L' msk      ⋄ L_s ← 'L' sel
    M ← {('M' new 0 '') wrap ⊃⍪/ (⊂ 0 f∆ ρ ⍬), ω}   ⋄ M_m ← 'M' msk      ⋄ M_s ← 'M' sel
    N ← {'N' new 0 (⍎ω)}                            ⋄ N_m ← 'N' msk      ⋄ N_s ← 'N' sel
    O ← {('O' new αα) wrap ⊃⍪/ ω}                   ⋄ O_m ← 'O' msk      ⋄ O_s ← 'O' sel
    P ← {'P' new 0 ω}                               ⋄ P_m ← 'P' msk      ⋄ P_s ← 'P' sel
    S ← {'S' new 0 ω}                               ⋄ S_m ← 'S' msk      ⋄ S_s ← 'S' sel
    V ← {'V' new αα ω}                              ⋄ V_m ← 'V' msk      ⋄ V_s ← 'V' sel
    Y ← {'Y' new 0 ω}                               ⋄ Y_m ← 'Y' msk      ⋄ Y_s ← 'Y' sel
    Z ← {'Z' new 1 ω}                               ⋄ Z_m ← 'Z' msk      ⋄ Z_s ← '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 _ign
   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
  semi ← aws _s (';' _tk _as ('a' V∘,∘⊃)) _s aws
   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
   Brk ← rbrk _s {α (Ex _opt _s (semi _s (Ex _opt) _any)) ω} _s lbrk _as ('i' E∘⌽)
   Idx ← Brk _s (_yes _as {P ,'['}) _s Atom _as (2 E∘⌽)
  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
                 (1 = +⌿ m) ∧ 2 > m ⍳ 1  :  0 (,⊂('F' new 1) wrap ⊃⊃ m ⌿ 1 □ ⍉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 ⍴ ⍬) ,⍨ 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}
  Dop_1 ← {α ((dop_1 _as P) _s Afx _as (2 O∘⌽)) ω}
  Dop_2 ← {α (Atom _s (dop_2 _as P) _s Afx _as (2 O∘⌽)) ω}
  Dop_3 ← (dop_3 _as P) _s Atom _as (2 O∘⌽) _o (dot _s jot _as (P∘⌽) _as (1 O))
   Bop ← {α (rbrk _s Ex _s lbrk _s (_yes _as {P ,'['}) _s Afx _as (2 O∘⌽)) ω}
   Afx ← Mop _o (Fnp _s (Dop_1 _o Dop_3 _opt) _as (⊃wrap/∘⌽)) _o Dop_2 _o Bop
   Trn ← {α (Afx _s ((Afx _o Idx _o Atom) _s (∇ _opt) _opt)) ω} _as ('t' F∘⌽)
  Bind ← {α (gets _s (name _as ⌽) _env (αα{(⊃⌽ω) αα ⍪ α}) _as (ωω new 'b', ⊢)) ω}
  Asgn ← gets _s Brk _s (name _as ⌽ _t (0 = Vt) _as ('a' V∘,∘⊃)) _as ('a' E∘⌽)
   Fex ← Afx _s (Trn _opt) _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 Asgn _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 ⍴ ⍬) Ns ∊{ω /⍨ ∧\ 'A' ≠ 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) ⍬ ,∘⊂⍨ ⊢ (⌿⍨∘~) 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, (⊂θ) ,⍨∘⍪ 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) ∧∘~ 'ui' ∊⍨∘⊃∘⊃ 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)
nv ← (¯1 ↓⍤1 ⊢), (¯1 ⊖ ≢ ⊃ ⊢ ,∘⊂⍨ (⊂'%u' '%f' '%u'), (⊂ '%u' '%i', ⊢), (⊂ (⊂'%u'), ⊢))¨∘v
lt ← (⊂θ) ,⍨ ⊢
val ← (n ⍳∘∪ n) ,¨ ⊢ (⊢ + (≢⊣) × 0 = ⊢) (⌈/ (⍳≢) ×⍤1 (∪n) ∘.((⊂⊣) ∊ ⊢) (n2f¨ v))
vag ← ∧∘~∘(∘.=⍨∘⍳ ≢)⍨ (∘.(((1 ⌷ ⊢) > 0 ⌷ ⊣) ∧ (0 ⌷ ⊢) < 1 ⌷ ⊣)⍨ val)
vae ← (∪n) (⊣ ,⍤0 ⊣ (⌷⍨⍤1 0)∘⊃ ((⊢ ,∘⊃ (⍳∘≢ ⊣) ~ ⊢ (≠⍨) (≢⊢) ↑ ⊣)/∘⌽ (⊂θ) ,∘↓ ⊢)) 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 ⌷ ⊣)/∘⌽ (⊂θ), ↑)⍤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' θ 0 1, (4 ρ 0) θ θ ,⍨ ⊢
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}
Ei ← {r l f ← ⊃ v ω ⋄ ((⊃ n ω) ('fn' var) ⊃⊃ e ω), '=', ((⊃⊃ v ω) ('fn' var) 1 ⊃ ⊃ e ω), ';', nl}
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 ρ θ ⋄ ⊂ (⍎ (⊃ t ω), ⍕ ⊃ k ω) ω}⍤1 ⊢ ω}

syms  ← ,¨ '+'     '-'     '×'     '÷'     '*'     '⍟'     '|'     'o'      '⌊'     '⌈'     '!'
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 ,← ,¨ '⌷'     '['     '⍳'     'ρ'     ','     '⍪'     'ϕ'     '⍉'      'ө'     '∊'     '⊃'
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 ≠ (≢∘ρ¨ ⊣) ⋄ 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 ρ ω : (cnm ω), α ⋄ 1 = ≢ω : lits ω ⋄ lita ω}
var  ← {α ≡ ,'α' : ,'l' ⋄ α ≡ ,'ω' : ,'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 ρ ⊂'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