AE

```
{- 20 {+ 10 10}}

{- 20 {+ 17 17}}

{- 20 {+ 3 3}}
```

WAE

```
{with {x 10}
  {- 20 {+ x x}}}

{with {x 17}
  {- 20 {+ x x}}}

{with {x 3}
  {- 20 {+ x x}}}
```

FIWAE

```
{deffun {f x}
  {- 20 {+ {+ x x}
           {+ x x}}}}
```

```
{f 10}

{f 17}

{f 3}
```

FIWAE

```
{deffun {f x}                    {f 10}
  {- 20 {twice
          {twice x}}}}           {f 17}

{deffun {twice y}                {f 3}
  {+ y y}}
```

F1WAE

```
{deffun {f x}                    {f 10}
  {- 20 {twice
          {twice x}}}}           {f 17}

{deffun {twice y}                {f 3}
  {+ y y}}
```

```
; interp : F1WAE list-of-FunDef -> num
```

F1WAE

```
{deffun {f x}                    {f 10}
  {- 20 {twice
          {twice x}}}}           {f 17}

{deffun {twice y}                {f 3}
  {+ y y}}
```

<FunDef> ::= {deffun {<id> <id>} <F1WAE>}

F1WAE

```
{deffun {f x}                    {f 10}
  {- 20 {twice
         {twice x}}}}            {f 17}

{deffun {twice y}                {f 3}
  {+ y y}}
```

```
<FunDef>  ::=  {deffun {<id> <id>} <F1WAE>}
<F1WAE>   ::=  …
           |   {<id> <F1WAE>}
```

F1WAE Grammar

```
<FunDef>  ::=  {deffun {<id> <id>} <F1WAE>}
```

NEW

```
<F1WAE>   ::=  <num>
           |   {+ <F1WAE> <F1WAE>}
           |   {- <F1WAE> <F1WAE>}
           |   {with {<id> <F1WAE>} <F1WAE>}
           |   <id>
           |   {<id> <F1WAE>}
```

NEW

F1WAE Datatypes

```
(define-type FunDef
  [fundef (fun-name symbol?)
          (arg-name symbol?)
          (body F1WAE?)])

(define-type F1WAE
  [num (n number?)]
  [add (lhs F1WAE?)
       (rhs F1WAE?)]
  ...
  [app (fun-name symbol?)
       (arg F1WAE?)])
```

F1WAE Interp

```
(define (interp a-wae fundefs)
  (type-case F1WAE a-wae
    [num (n) n]
    [add (l r) (+ (interp l fundefs)
                  (interp r fundefs))]
    ...
    [app (name arg-expr)
         ...]))
```

F1WAE Interp

```
(define (interp a-wae fundefs)
  (type-case F1WAE a-wae
    [num (n) n]
    [add (l r) (+ (interp l fundefs)
                  (interp r fundefs))]
    ...
    [app (name arg-expr)
         ...]))


 (test (interp (add (num 1) (num 1))
               empty)
       2)
```

F1WAE Interp

```
(define (interp a-wae fundefs)
  (type-case F1WAE a-wae
    [num (n) n]
    [add (l r) (+ (interp l fundefs)
                  (interp r fundefs))]
    ...
    [app (name arg-expr)
         ...]))


(test (interp (add (num 1) (num 1))
              (list
               (fundef 'f 'x
                       (add (id 'x) (num 3)))))
      2)
```

F1WAE Interp

```
(define (interp a-wae fundefs)
  (type-case F1WAE a-wae
    [num (n) n]
    [add (l r) (+ (interp l fundefs)
                  (interp r fundefs))]
    ...
    [app (name arg-expr)
         ...]))
```

```
(test (interp (app 'f (num 1))
              (list
               (fundef 'f 'x
                       (add (id 'x) (num 3)))))
      4)
```

F1WAE Interp

```
(define (interp a-wae fundefs)
  (type-case F1WAE a-wae
    [num (n) n]
    [add (l r) (+ (interp l fundefs)
                  (interp r fundefs))]
    ...
    [app (name arg-expr)
         ...]))

(test (interp (app 'f (num 10))
              (list
               (fundef 'f 'x
                       (sub (num 20)
                            (app 'twice (id 'x))))
               (fundef 'twice 'y
                       (add (id 'y) (id 'y))))
              0))
```

F1WAE Interp

```
(define (interp a-wae fundefs)
  (type-case F1WAE a-wae
    [num (n) n]
    [add (l r) (+ (interp l fundefs)
                  (interp r fundefs))]
    ...
    [app (name arg-expr)
         ... (interp arg-expr fundefs) ...]))
```

F1WAE Interp

```
(define (interp a-wae fundefs)
  (type-case F1WAE a-wae
    [num (n) n]
    [add (l r) (+ (interp l fundefs)
                  (interp r fundefs))]
    ...
    [app (name arg-expr)
         ... (lookup-fundef name fundefs)
         ... (interp arg-expr fundefs) ...]))
```

```
; lookup-fundef : symbol list-of-FunDef -> FunDef
```

F1WAE Interp

```
(define (interp a-wae fundefs)
  (type-case F1WAE a-wae
    [num (n) n]
    [add (l r) (+ (interp l fundefs)
                  (interp r fundefs))]
    ...
    [app (name arg-expr)
         (local [(define a-fundef
                   (lookup-fundef name fundefs))]
           (interp (subst (fundef-body a-fundef)
                          (fundef-arg-name a-fundef)
                          (interp arg-expr fundefs))
                   fundefs))]))
```

Lookup

```
; lookup-fundef : symbol list-of-FunDef -> FunDef
(define (lookup-fundef name fundefs)
  ...)
```

Lookup

```
; lookup-fundef : symbol list-of-FunDef -> FunDef
(define (lookup-fundef name fundefs)
  (cond
   [(empty? fundefs)
    ...]
   [else
    ... (first fundefs)
    ... (lookup-fundef name (rest fundefs))
    ...]))
```

Lookup

```
; lookup-fundef : symbol list-of-FunDef -> FunDef
(define (lookup-fundef name fundefs)
  (cond
   [(empty? fundefs)
    (error 'interp "unknown function")]
   [else
    (if (symbol=? name (fundef-fun-name
                        (first fundefs)))
        (first fundefs)
        (lookup-fundef name (rest fundefs)))]))
```

Subst

```
; subst : F1WAE symbol num -> F1WAE
(define (subst a-f1wae sub-id val)
  (type-case F1WAE a-f1wae
    ...
    [app (fun-name arg)
         (app fun-name (subst arg sub-id val))]))
```