Object-Oriented Programming

***Solutions***

Problems

1. Write a food class

   - Input state is the name, nutrition value, and good-until time.
   - Additional state is the age of the food, initially 0.
   - Methods are:
     - NAME - returns the name of the food
     - AGE - returns the age of the food
     - SIT-THERE - takes an amount of time, and increases the age of the food by the amount.
     - EAT - return the nutrition if the food is still good; 0 otherwise.

```scheme
(define food
  (make-class
   'food
   '(name nutrition good-until age)
   root-object
   (make-methods
    'CONSTRUCTOR
      (lambda (name nutrition good-until)
        (write-state! 'name name)
        (write-state! 'nutrition nutrition)
        (write-state! 'good-until good-until)
        (write-state! 'age 0))
    'NAME
      (lambda () (read-state 'name))
    'AGE
      (lambda () (read-state 'age))
    'SIT-THERE
      (lambda (time)
        (write-state! 'age (+ time (read-state 'age))))
    'EAT
      (lambda ()
        (if (< (read-state 'age) (read-state 'good-until))
          (read-state 'nutrition)
          0))))
```

2. Write an aged-food class
• Input state is the same as the food class, with an additional parameter, which is the good-after time.
• Should inherit from the food class.
• Methods are:
  – SNIFF - returns #t if it has aged enough to be good.
  – EAT - returns 0 if the food is not good yet; otherwise behaves like normal food.

(define aged-food
  (make-class
   'aged-food
   '(good-after)
   food
   (make-methods
    'CONSTRUCTOR
    (lambda (name nutrition good-until good-after)
      (super 'CONSTRUCTOR name nutrition good-until)
      (write-state! 'good-after good-after))
    'SNIFF
    (lambda ()
      (> (invoke self 'AGE) (read-state 'good-after)))
    'EAT
    (lambda ()
      (if (invoke self 'SNIFF)
          (super 'EAT)
          0)))))

3. Extend the object system to support dynamic mixin classes. A “mixin” is when one class, after being defined, can be modified to include methods definitions from some other class. This effectively allows a class to inherit from multiple classes, and is also sometimes called a role or an abstract base class.

(define (mixin! from to)
  (cond ((not (class? from))
          (error "first arg to mixin! must be a class"))
        ((class? to)
         (set-car! (cddddr to) (append (class-methods to)
                                        (class-methods from)))
         (error "second arg to mixin! must be a class")))))

1Technically, since this is only adding the methods of the other class, and not its state, this is a “trait” and not a mixin.
2Mixins actually first appeared in an object system for Lisp Machine Lisp in 1982; the name was inspired by Steve's Ice Cream Parlor in Somerville, which allowed toppings to be mixed into their ice cream.
4. Further extend the system to support mixins on instances, in addition to classes. That is, some particular instance of aged-food (a stinky-cheese-wheel, for instance) might mix in the methods of the round trait to get the ROLL method.

```scheme
(define (mixin! from to)
  (cond ((not (class? from))
        (error "mixin! takes a class as the first arg"))
        ((class? to)
         (set-car! (cddr to)
                   (append (class-state to)
                           (class-state from)))
         (set-car! (cddddr to)
                   (append (class-methods to)
                           (class-methods from))))
        ((instance? to) ;; ADDED
         (set-car! (cddr to)
                   (make-class (gensym)
                               '()
                               (instance-class to)
                               (class-methods from)))
         (else
          (error "unknown second type to mixin!")))))
...or:

(define (instance-methods inst) ;; ADDED
  (fourth inst))

(define (make-instance class . args)
  (let ((inst
         (list 'instance
               (map (lambda (x) (list x #f))
                    (collect-state class))
               class
               '())))) ;; ADDED
    (if (has-method? inst 'CONSTRUCTOR)
        (apply invoke inst 'CONSTRUCTOR args)
        (void))
  inst))

(define (find-instance-method methodname instance) ;; ADDED
  (let ((result (assq methodname (instance-methods instance))))
    (if result
        (second result)
        #f)))

(define (has-method? instance method)
  (define (helper class)
    (cond ((not (class? class)) #f)
          (else (helper (class-states class))))
  (helper (cddr inst)))

```

4. Further extend the system to support mixins on instances, in addition to classes. That is, some particular instance of aged-food (a stinky-cheese-wheel, for instance) might mix in the methods of the round trait to get the ROLL method.
((find-class-method method class) #t)
  (else (helper (class-parent class))))
(or (find-instance-method method instance) ;; ADDED
  (helper (instance-class instance))))

(define (invoke instance method . args)
  (fluid-let ((self instance))
    (let ((proc (find-instance-method method self))) ;; ADDED
      (if proc
        (fluid-let ((super (lambda (method . args)
                             (method-call
                              (instance-class instance)
                             method args))))
          (apply proc args))
          (method-call (instance-class instance) method args)))))

(define (mixin! from to)
  (cond ((not (class? from))
        (error "first arg to mixin! must be a class"))
        ((class? to)
          (set-car! (cddddr to) (append (class-methods to)
                                       (class-methods from))))
          ;; ADDED
        ((instance? to)
          (set-car! (cdddr to) (append (instance-methods to)
                                       (class-methods from))))
          (else
            (error "unknown second arg to mixin!"))))