Sample midterm 2 #3

Problem 1 (What will Scheme print?)

What will Scheme print in response to the following expressions? If an expression produces an error message, you may just write "error"; you don't have to provide the exact text of the message. **Also, draw a box and pointer diagram for the value produced by each expression.**

```
(append (list 'a 'b) '(c d))
```

```
(cons (list 'a 'b) (cons 'c 'd))
```

```
(list (list 'a 'b) (append '(c) '(d)))
```

```
(cdar '((1 2) (3 4)))
```

Problem 2 (Tree recursion)

The following definition comes from page 116 of *SICP*:

```
(define (accumulate op initial sequence)
  (if (null? sequence)
      initial
      (op (car sequence)
          (accumulate op initial (cdr sequence)))))
```

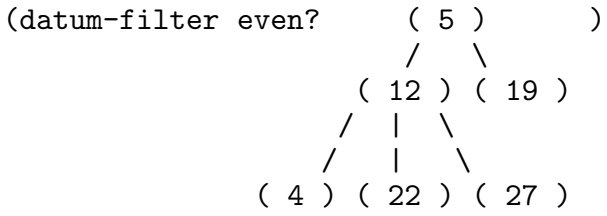
In this problem you're going to extend the idea of accumulation from sequences to "deep lists": lists of lists of lists to arbitrary depth. Write `deep-accumulate`, a function of three arguments: a two-argument function, an initial value, and a list structure. It should work like this:

```
> (deep-accumulate + 0 '(3 (4 (5) ((6) 7) 8) (9 10)))
52
```

Problem 3 (Tree recursion)

Write the function `datum-filter` which, given a predicate and a Tree, returns a list of all the `datum`s in the Tree that satisfy the predicate (in any order). We are using general Trees (trees that can have any number of children) as defined in lecture. We are *not* using binary trees. The function should return the empty list for any Tree in which no `datum`s satisfy the predicate. You may use helper procedures.

For example:



returns the list `(12 4 22)` in any order.

Problem 4 (Message passing)

Consider the following message-passing implementation of rational numbers:

```
(define (make-rat num den)
  (define (dispatch msg)
    (cond ((eq? msg 'numer) num)
          ((eq? msg 'denom) den)
          (else (error "Unknown op -- MAKE-RAT" msg)) ))
  dispatch)
```

Compare this with the complex number implementation on page 186 of the text. Suppose we are given analogous procedures `make-integer` and `make-real`. You are going to modify `make-rat`, and write some auxiliary procedures, to achieve three goals:

(a) In the conventional and data-directed styles of programming, we could take an arbitrary number and find out what type it is, by using the `type-tag` function. This function would return a symbol such as `rational` or `complex` to identify the type of its argument. In the message-passing implementation, a number is no longer a pair whose car is the type name. We want a `type` function that will allow us to find out the type of a message-passing-style number.

(b) For homework you created a `raise` operation that could be applied to a number to convert it to the next higher type in the tower of types. You did this in the context of data-directed programming, using a table. We want to implement this `raise` operation in message-passing style. In particular, we want to allow a rational number to be raised to type `real`.

(c) Once we have the idea of raising numbers, it makes sense that we should be able to ask the same questions about a given number that we could ask about higher types. For example, we'd like

```
(real-part (make-rat 3 4))   ⟹  0.75
(imag-part (make-rat 3 4))   ⟹  0
```

But we don't want to have to re-implement all the messages for real numbers and complex numbers within `make-rat`. Instead, if `make-rat` doesn't recognize a message, it should raise the number and send the message to the raised number.

Rewrite `make-rat` to meet these three goals, and write the procedures `type` (for goal a) and `raise` (for goal b).

Problem 5 (Object oriented programming)

We are going to prepare a simulation of an FM car radio. To simplify the problem we'll restrict our attention to tuning, not to volume or balance or anything else a radio does. This radio features digital tuning. There are six buttons that can be preset to particular stations; for manual tuning, there are `up` and `down` buttons that move to the next higher or lower frequency. (FM frequencies are measured in megahertz and have values separated by 0.2: 88.1, 88.3, 88.5, 88.7, 88.9, 90.1, etc.) To simplify the problem further, we'll ignore the boundary problem of what to do when you're at the lowest assigned FM frequency and try to go `down` below that frequency. Just pretend you can keep going up or down forever.

Use the OOP language (`define-class` and so on).

(a) Create a `button` object class that accepts these messages:

`set-freq! 93.3`	sets the button's remembered frequency
`freq`	returns the remembered frequency

The initial frequency should be zero (because the buttons don't have settings initially).

(b) Create a `radio` object class that has six buttons, numbered 0 through 5, and accepts these messages:

`set-button! 3`	sets button 3 to the radio's current frequency
`push 3`	sets the radio to button 3's frequency
`up`	sets the radio to the next higher frequency
`down`	sets the radio to the next lower frequency
`freq`	returns the radio's current frequency

The radio's initial frequency should be 90.7 MHz. Points to remember: Your radio has to use six of your button objects; you needn't check for invalid argument values in the methods. **Hint:** Give your radio a list of six buttons, and use `list-ref` to get the one you want.