

1. Suppose  $f$  is a function,  $l$  and  $h$  are integers, with  $l \leq h$ . Write a procedure `monotone?` that takes  $f$ ,  $l$ , and  $h$  as its three arguments and returns `#t` if  $f(i) \leq f(i+1)$  for all  $l \leq i < h$ , or if  $f(i) \geq f(i+1)$  for all  $l \leq i < h$ , and returns `#f` otherwise. For example, suppose `square` is the following procedure

```
(define square (lambda (x) (* x x)))
```

then

```
(monotone? square -3 -1) ⇒ #t
```

```
(monotone? square 13 15) ⇒ #t
```

```
(monotone? square -3 5) ⇒ #f
```

2. Consider the three procedures:

```
(define make-longer-by-k
  (lambda (k f)
    (lambda (x)
      (+ k (f x)))))
```

```
(define twice
  (lambda (x)
    (+ x x)))
```

```
(define mystery (make-longer-by-k 6 twice))
```

For each of the three expressions below, indicate whether its value is a number or a procedure. If the value is a procedure, indicate how many arguments it gets. If the value is a number, what number is it?

(a) `(mystery 3)`

(b) `((make-longer-by-k 7 mystery) 4)`

(c) `(make-longer-by-k 5 mystery)`

3. Suppose we have an abstract data type for Gustie alumnus. This should include a constructor called `make-alumnus`, three selectors called `name`, `major`, and `year-graduate`, and a procedure `display-alumnus` for displaying an alumnus nicely. For example, we could display a Gustie alumnus like so

```
% (display-alumnus (make-alumnus "James L. Peterson" 'biology 1964))
James L. Peterson
BIOLOGY
1964
```

(a) Implement the constructor `make-alumnus` using procedure representation. Then write the selectors `name`, `major`, and `year-graduate`.

(b) Do part (a) again but this time use (dotted) pairs instead of procedure representation.

4. Consider the following procedures.

```
(define f
  (lambda (n)
    (* (g (* 3 n) (+ n 1))
       (h n))))
(define g
  (lambda (m n)
    (if (= m 0)
        n
        (* (g (- m 1) n) (h n))))))
(define h
  (lambda (n)
    (if (= n 0)
        1
        (* (h (- n 1)) n))))
```

- (a) If we call `(f n)`, exactly how many multiplications get done? Justify your answer.  
(b) Give the asymptotic running time (in  $\Theta$  notation) of procedure `f`.