Midterm exam of Principles of Programming Languages, 2016.11.21

Notes:
- Total available time: 1h.
- You may use any written material you need, and write in Italian, if you prefer.
- You cannot use electronic devices during the exam.

Exercise 1 (6 points)

The *fold* operations are very general, and can be used to implement many higher order functions.
1) Define *map* as a fold (left or right, your choice).
2) Define *filter* as a fold (left or right, your choice).

Exercise 2 (6 points)

The function *(cos-min i j)*, given below, returns the integer in the range [i,j] with the smallest cosine.

```
(define (cos-min i j)
  (if (= i j)
      j
      (let ((k (cos-min (+ i 1) j)))
        (if (< (cos i) (cos k))
            i
            k))))
```

Implement a tail-recursive version of *cos-min*.

Solutions

Es 1
```
(define (fmap f l)
  (foldr (lambda (x y)
           (cons (f x) y))
         '()
         l))

(define (ffilter p l)
  (foldr (lambda (x y)
           (if (p x)
               (cons x y)
               y))
         '()
         l))


Es 2
(define (cos-min-tail i j)
  (define (helper i j k)
    (if (= i j)
        k
        (helper (+ 1 i) j
             (if (< (cos i) (cos k)) i k))))
  (helper (+ 1 i) j i))
```