CS3:
Introduction to Symbolic Programming

Lecture 10:
Miniproject #3
Tree recursion
Midterm 2

Fall 2007

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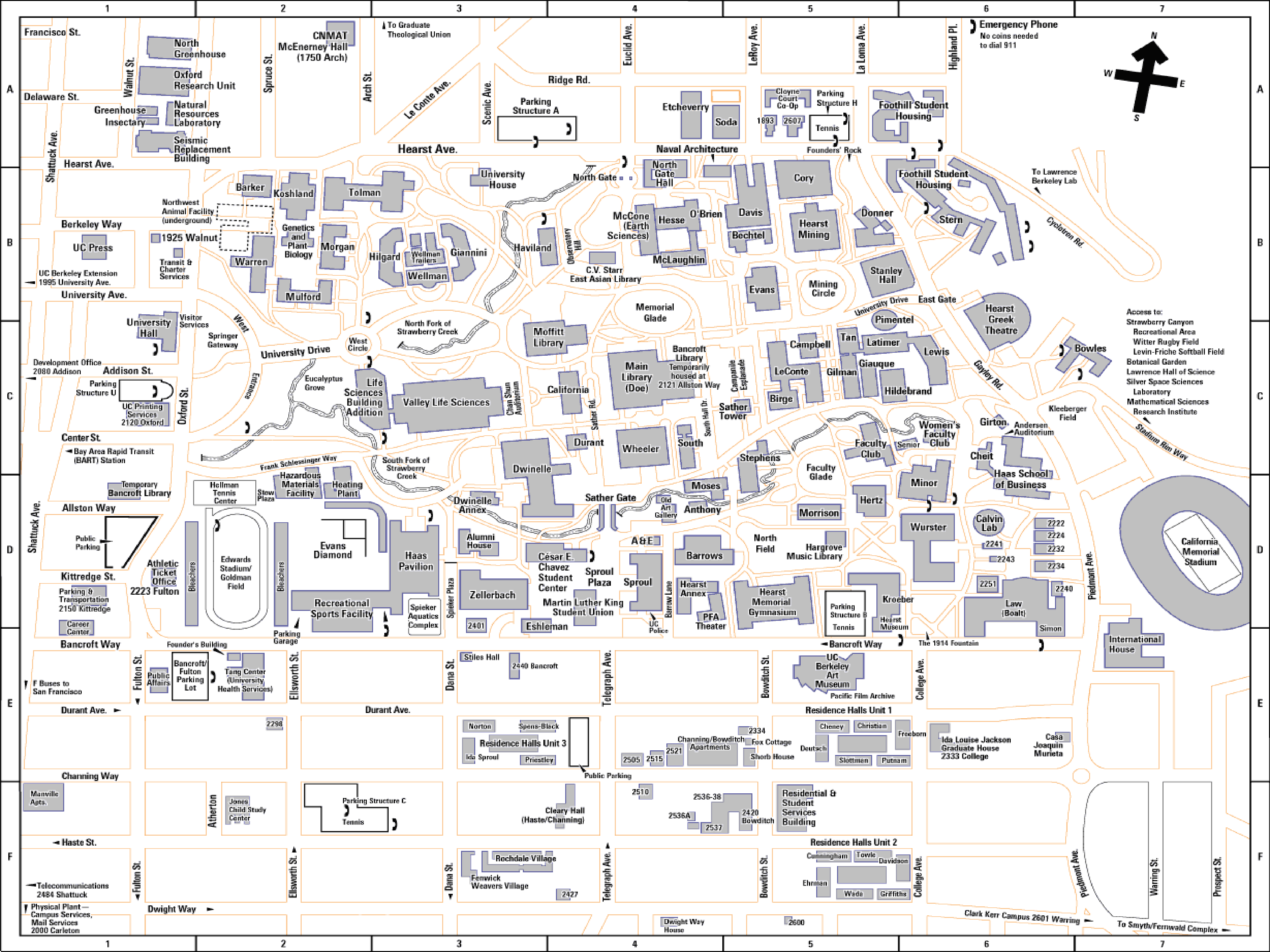
Schedule

9	Oct 22-26	Lecture: Advanced HOF Lab: Difference between Dates, Tic Tac Toe Miniproject #3 is introduced
10	Oct 29 – Nov 2	Lecture: Tree Recursion, Midterm review Lab: Tree recursions Finish Miniproject #3 Be sure to finish the Survey Reading: "Counting Change" case study
11	Nov 5–9	Lecture: *Midterm #2* Lab: Introduction to Lists
12	Nov 12–16	Lecture: Lists, Sequential Programming Lab: Advanced Lists, Sequential Programming Find partners for the Big Project
13	Nov 19–23	Lecture: Introduction to the Big Project Lab: Work on the Big Project: checkoff #1

Midterm #2

- **Next Week (Nov 5th)**
  - Next week, 90 minutes (4:10-5:40).
  - Note: daylight savings time starts that week!
  - Room **Genetics and Plant Bio 100**
  - Open book, open notes, etc.
  - Check for practice exams and solution on the course portal and in the reader.
- **Midterm 2 review session**
  - Saturday, 2-4 pm
  - 306 Soda (as last time)



1
2
3
4
5
6
7
A
B
C
D
E
F
Francisco St.
North Greenhouse
Oxford Research Unit
Walnut St.
Delaware St.
Greenhouse
Insectary
Natural Resources Laboratory
Seismic Replacement Building
Shattuck Ave.
Hearst Ave.
CNMAT
McEnerney Hall
(1750 Arch)
Spruce St.
Arch St.
Le Conte Ave.
To Graduate Theological Union
Scenic Ave.
Parking Structure A
Ridge Rd.
Euclid Ave.
LeRoy Ave.
La Loma Ave.
Highland Pl.
Emergency Phone
No coins needed to dial 911
N
W
E
S
Etcheverry
Soda
Cloyne Court Co-Op
Parking Structure H
1893
2607
Tennis
Foothill Student Housing
Naval Architecture
Founders' Rock
North Gate Hall
North Gate
Cory
Barker
Koshland
Tolman
University House
Northwest Animal Facility (underground)
Berkeley Way
1925 Walnut
UC Press
Transit & Charter Services
Genetics and Plant Biology
Morgan
Warren
Hilgard
Wellman Trailers
Giannini
Wellman
Mulford
Haviland
Observatory Hill
C.V. Starr East Asian Library
McCone (Earth Sciences)
Hesse
O'Brien
Davis
Bechtel
McLaughlin
Hearst Mining
Donner
Stern
To Lawrence Berkeley Lab
Cyclotron Rd.
Stanley Hall
Mining Circle
Evans
Memorial Glade
University Drive
East Gate
Hearst Greek Theatre
UC Berkeley Extension 1995 University Ave.
University Ave.
University Hall
Visitor Services
Springer Gateway
West Entrance
West Circle
North Fork of Strawberry Creek
Moffitt Library
Bancroft Library Temporarily housed at 2121 Allston Way
Main Library (Doe)
Campanile Esplanade
Pimentel
Tan
Latimer
Campbell
Lewis
Bowles
Access to:
Strawberry Canyon Recreational Area
Witter Rugby Field
Levin-Friche Softball Field
Botanical Garden
Lawrence Hall of Science
Silver Space Sciences Laboratory
Mathematical Sciences Research Institute
Development Office 2080 Addison
Addison St.
Parking Structure U
UC Printing Services 2120 Oxford
Oxford St.
Eucalyptus Grove
Life Sciences Building Addition
Valley Life Sciences
Chan Shun Auditorium
California
Sather Rd.
South Hall Dr.
Sather Tower
LeConte
Giauque
Gilman
Birge
Hildebrand
Gayley Rd.
Kleeberger Field
Girton
Andersen Auditorium
Stadium Rim Way
Center St.
Bay Area Rapid Transit (BART) Station
Frank Schlessinger Way
South Fork of Strawberry Creek
Durant
Wheeler
South
Women's Faculty Club
Faculty Club
Senior
Stephens
Faculty Glade
Cheit
Haas School of Business
Temporary Bancroft Library
Hellman Tennis Center
Stow Plaza
Hazardous Materials Facility
Heating Plant
Dwinelle
Dwinelle Annex
Sather Gate
Old Art Gallery
Moses
Anthony
Minor
Hertz
Morrison
Allston Way
Shattuck Ave.
Public Parking
Edwards Stadium/ Goldman Field
Bleachers
Evans Diamond
Haas Pavilion
Alumni House
A&E
Barrows
North Field
Hargrove Music Library
Wurster
Calvin Lab
2222
2224
2232
2234
2241
2243
2251
2240
California Memorial Stadium
Piedmont Ave.
Athletic Ticket Office
2223 Fulton
Kittredge St.
César E. Chavez Student Center
Sproul Plaza
Sproul
Barrow Lane
Hearst Annex
PFA Theater
Hearst Memorial Gymnasium
Parking Structure B
Tennis
Kroeber
Hearst Museum
Law (Boalt)
Simon
Parking & Transportation 2150 Kittredge
Career Center
Recreational Sports Facility
Spieker Aquatics Complex
Spieker Plaza
Zellerbach
Martin Luther King Student Union
2401
Eshleman
UC Police
Parking Garage
Bancroft Way
Founder's Building
The 1914 Fountain
International House
Fulton St.
Public Affairs
Bancroft/ Fulton Parking Lot
Tang Center (University Health Services)
Ellsworth St.
Dana St.
Stiles Hall
2440 Bancroft
Telegraph Ave.
Bowditch St.
UC Berkeley Art Museum
Pacific Film Archive
College Ave.
F Buses to San Francisco
Durant Ave.
Residence Halls Unit 1
2298
Norton
Spens-Black
Residence Halls Unit 3
Ida Sproul
Priestley
Channing/Bowditch Apartments
2334
Fox Cottage
Sherb House
2505
2515
2521
Cheney
Christian
Freeborn
Deutsch
Slottman
Putnam
Ida Louise Jackson Graduate House 2333 College
Casa Joaquin Murieta
Channing Way
Public Parking
Manville Apts.
Atherton
Jones Child Study Center
Parking Structure C
Tennis
Cleary Hall (Haste/Channing)
2510
2536-38
2536A
2537
2420 Bowditch
Residential & Student Services Building
Haste St.
Residence Halls Unit 2
Rochdale Village
Fenwick Weavers Village
2427
Cunningham
Towle
Davidson
Ehrman
Wade
Griffiths
Warring St.
Prospect St.
Telecommunications 2484 Shattuck
Physical Plant — Campus Services, Mail Services 2000 Carleton
Dwight Way
Dwight Way House
2600
Clark Kerr Campus 2601 Warring
To Smyth/Fernwald Complex

What does midterm #2 cover?

- Advanced recursion (accumulating, multiple arguments, etc.).
- Tree-recursion (from <u>this</u> week)
- All of higher order functions
- Those "big" homeworks (bowling, compress, and occurs-in)
- Elections and number-name miniprojects
- Reading and programs:
  - Change making, Roman numerals
  - Difference between dates #3 (HOF),
  - Tic-tac-toe
- SS chapters 14, 15, 7, 8, 9, 10
- Everything before the first Midterm (although, this won't be the focus of a question)

Testing in miniproject #3

- There is a bit of contradiction in the instructions:
  - Put all of your testing in `winner-tests.scm`, rather than above each function in `winner.scm`
  - You still need to test each helper procedure!
- Use “send region” in emacs to test many things at once.
- Write some procedures to help you test…

The last of Advanced HOF

`every` containing `every`

- You can mimic 2-stage recursion, applying a function to each letter of each word.

- You can get combinatoric effects:

```
(define (pair-all sent)
  (every (lambda (one)
           (every (lambda (two)
                    (word one two))
                  sent))
         sent))

(pair-all '(a b c)) → ???
```

every containing every containing...

```
(make-kindergarten-words '(s t) '(a o))
      ➔ (sas sat sos sot tas tat tos tot)
(make-kindergarten-words '(l n k t s) '(a e i o u))
      ➔ 225 words!

(define (make-kindergarten-words consonants vowels)
  (every (lambda (c)
            (every (lambda (v)



                  vowels))
        consonants))
```

Tree Recursion

What will happen?

- **What will `countem` return for n=1, 2, …?**

```
(define (countem n)
    (if (= n 0)
        '()
        (se (countem (- n 1))
            n
            (countem (- n 1)))))
```

Tree recursion

A recursive technique in which more than one recursive call is made within a recursive case.

Pascal's triangle

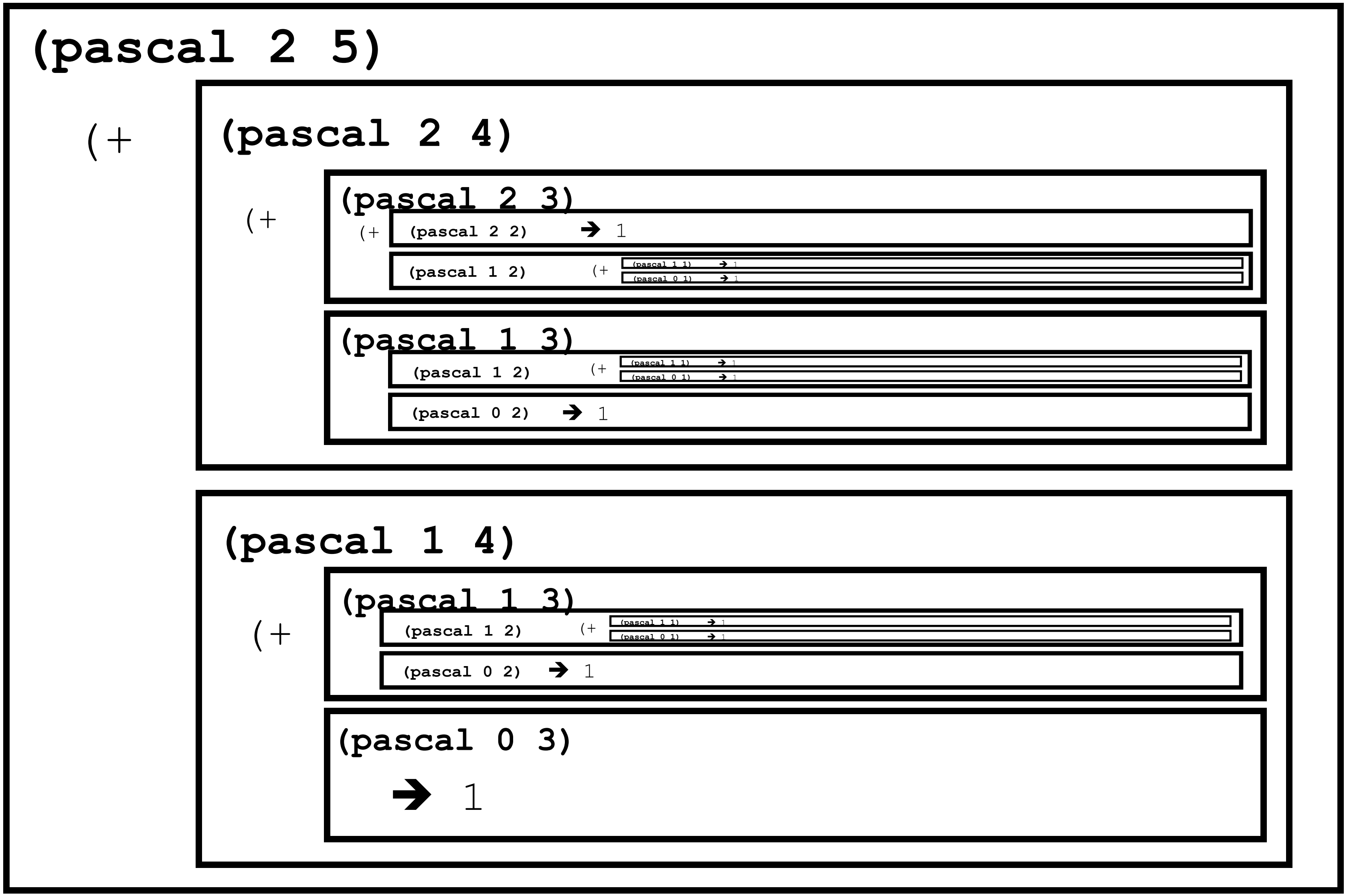
		columns (C)						
r o w s (R)		0	1	2	3	4	5	...
	0	1						...
	1	1	1					...
	2	1	2	1				...
	3	1	3	3	1			...
	4	1	4	6	4	1		...
	5	1	5	10	10	5	1	...
	...	...	...	...	...	...	...	...

Pascal's Triangle

- How many ways can you choose C things from R choices?
- Coefficients of the (x+y)^R: look in row R
- etc.

```
(define (pascal C R)
  (cond
    ((= C 0) 1)      ;base case
    ((= C R) 1)      ;base case
    (else            ;tree recurse
     (+ (pascal    C     (- R 1))
        (pascal (- C 1) (- R 1))
     )))
```

> (pascal 2 5)



(pascal 2 5)
(+
(pascal 2 4)
(+
(pascal 2 3)
(+
(pascal 2 2) → 1
(pascal 1 2)
(+
(pascal 1 1) → 1
(pascal 0 1) → 1
(pascal 1 3)
(pascal 1 2)
(+
(pascal 1 1) → 1
(pascal 0 1) → 1
(pascal 0 2) → 1
(pascal 1 4)
(+
(pascal 1 3)
(pascal 1 2)
(+
(pascal 1 1) → 1
(pascal 0 1) → 1
(pascal 0 2) → 1
(pascal 0 3)
→ 1

Chips and Drinks

"I have some bags of chips and some drinks. How many different ways can I finish all of these snacks if I eat one at a time?

`(snack 1 2)` → `3`

- This includes (chip, drink, drink), (drink, chip, drink), and (drink, drink, chip).

`(snack 2 2)` → `6`

- (c c d d), (c d c d), (c d d c)
  (d c c d), (d c d c), (d d c c)

A variable number of recursive calls…

- **Consider "Joe numbers":**
  - The n^{th} joe-number is the sum of all the joe-numbers under it (i.e., joe^{n-1} to joe^{1}).
  - Joe^{1} is simply 1.

- **Write a procedure to calculate Joe^{n}.**

  - A procedure `down-from` that, given `n`, returns a sentence of numbers from `n` to `1` should be useful. And easy to write!
    - `(down-from 6)` ➔ `(6 5 4 3 2 1)`

Problems

binary

- **Write `binary`, a procedure to generate the possible binary numbers given `n` bits.**

```
(binary 1)→(0 1)
(binary 2)→(00 01 10 11)
(binary 3)→(000 001 010 011 100 101 110 111)
```