About Exam 1

The exam is closed-book, closed-notes except for one (8.5×11-inch) sheet of notes.

The exam is likely to be about 75 points – intended to be budgeted as one point per minute – and five questions, highlighting different concepts we’ve covered. E.g., they might be:

1. Follow the design recipe. Given a problem description, design a function following the steps of the design recipe: data definitions, signature, purpose statement, function header, tests, function template, and finally, the finished function.

2. You be the stepper. Given a function definition and function application, trace the evaluation of the function being applied. The function may contain a cond expression.

3. Given a structure definition, provide examples of this type of structure; name and give the signatures for the constructor, predicate, and selector functions automatically created; and create a template function for the given structure.

4. Given a set of data definitions for data with varieties (like the data definitions we saw for Animal, Rabbit, Dillo, and Ant), write function(s) following the steps of the Design Recipe. Remember: The shape of the data determines the shape of the function(s). This question may involve a “wish list” (helper) function from following the Design Recipe.

5. Given a data definition for a list of data items, e.g., numbers or structures, using the design recipe. Your solution will involve examples of data, templates, functions with signature and purpose statements, and tests.
Problem 1

If you know what year of school someone is in, you can predict what kind of school they’re likely to be in. Someone in fifth grade or below in the US is likely to attend an elementary school. Otherwise, if they’re in eighth grade or below, they’re likely to attend a middle school. And if they’re in twelfth grade or below, they’re in high school.

a. Give data definitions for SchoolGrade and SchoolType.

b. Write a template for a function that consumes a SchoolGrade.

c. Give the signature and purpose for a function that returns the school type for a given school grade.

d. Give two test cases for your function.

e. Define the function body by filling in the missing parts of the template.
Problem 2

Write the step-by-step computation that would be taken if you ran this program in the DrRacket Stepper, *underlining the portion of the expression in each step to be evaluated in the next step*, and separating each step with an arrow (⇒).

```
(define (f n)
  (cond [(> n 5) (sqr (- n 2))]
        [else (+ n 3)])

(f (* 3 2))
```
Problem 3

Suppose you want to write a program that works on music files. You might design a data definition that uses a structure for representing the “metadata” of a song, i.e., properties that aren’t part of the song itself:

\[
\text{(define-struct song [title artist year have?])}
\]

;; A Song is (make-song String String Number Boolean)

a. Write the signatures for the functions automatically created by the define-struct.

b. Give an example of a Song.

c. Write a template for a function that takes a Song as input.
Problem 4

Consider the following structures and data definition:

```
(define-struct circle [radius])
(define-struct square [length])
;; A Shape is one of:
;; - (make-circle Number)
;; - (make-square Number)
```

a. Define the function `circle-area` that computes the area of a circle, which is $\pi r^2$.

b. Define the function `square-area` that computes the area of a square, which is the square (!) of the length of its side.

c. Define the function `shape-area` that takes any `Shape` as input and computes its area.
Problem 5

In the run-up to the election, you've been hired as a consultant for a major political candidate. The campaign keeps track of donations using the following data definition:

```
(define-struct donation [donor amount])
```

;; A Donation is one of:
;; - Number
;; - (make-donation String Number)
;; Where a simple number represents an anonymous donation.

;; A ListOfDonations is one of:
;; - '()
;; - (cons Donation ListOfDonations)

The rules of campaign donation declare that a single contributor may only donate $2,800 to a given campaign. Furthermore, anonymous donations are limited to $50.

a. The first task you are given is to design a program any-bad-donations? that will consume a list of donations and return true if any of the donations on the list are illegal ones.

To make things simpler, you should first design a helper function bad-donation? that answers this question for a single donation.
b. Some unscrupulous special-interest groups are attempting to get around the laws on campaign donations by making multiple donations. For example, the wealthy but unscrupulous donor "Netochka" might try to make two donations of $2,800 each:

```
(cons (make-donation "Netochka" 2800)
     (cons (make-donation "Netochka" 2800)
           ...
     ))
```

Design a program donor-total that will consume the name of a donor and a list of donors and produce the total amount donated by that donor. For example, it would tell us that the total amount donated by donor "Netochka", given the list of donors above, is $5,600, which violates the donation limits.