Example Set 1

0.1 Evaluate by substitution (left-to-right, innermost order):

Let:

$$A_{circle}(r) = \pi r^2$$
$$V_{torus}(A, R) = A(2\pi R)$$
$$V_{cylinder}(h, A) = Ah$$
$$H_{cone}(h) = \frac{h}{3}$$
$$V_{cone}(A, H) = AH$$

1. $V_{torus}(A_{circle}(H_{cone}(3)), 2)$:

   $V_{torus}(A_{circle}(H_{cone}(3)), 2)$
   $V_{torus}(A_{circle}(\frac{3}{3}), 2)$
   $V_{torus}(A_{circle}(1), 2)$
   $V_{torus}(\pi(1)^2, 2)$
   $V_{torus}(\pi, 2)$
   $\pi(2\pi(2))$
   $4\pi^2$

2. $V_{cylinder}(4, A_{circle}(2))$:

   $V_{cylinder}(4, A_{circle}(2))$
   $V_{cylinder}(4, \pi(2)^2)$
   $V_{cylinder}(4, 4\pi)$
   $4(4\pi)$
   16π

3. $V_{cone}(A_{circle}(3), H_{cone}(9))$:

   $V_{cone}(A_{circle}(3), H_{cone}(9))$
   $V_{cone}(\pi(3)^2, H_{cone}(9))$
   $V_{cone}(9\pi, H_{cone}(9)))$
   $V_{cone}(9\pi, \frac{9}{3})$
   $V_{cone}(9\pi, 3)$
   $9\pi(3)$
   27π

Note that the forumulas for cones, cylinders and torii have been altered to fit this question.

0.2 Convert the following expressions from infix to prefix (use Racket syntax):

1. $\frac{1}{2}mv^2$

(* (/ 1 2) (* m (* v v)))

2. $\frac{n^2+1}{n-1}$

(/ (+ (* n n) 1) (- n 1))

3. $\sqrt{(r_1 - r_2)^2 + (g_1 - g_2)^2 + (b_1 - b_2)^2}$

($\sqrt{}$ (+ (+ (expt (- r_1 r_2) 2) (expt (- g_1 g_2) 2)) (expt (- b_1 b_2) 2)))

0.3 Evaluate the following expressions in DrRacket using inexact numbers:

1. $2\pi^2$

(* 2 (* pi pi))
#i19.739208802178716

2. $\sqrt{4\pi - 100}$

(sqrt (- (* 4 pi) 100))
#i0+9.35059135371911

3. $sin(\frac{1}{\pi})$

(sin (/ 1 pi))
#i0.31296179620778664

0.4 What error, if any, do these Racket expressions produce?

1. (/ 3 (+ 1 -1))

/: division by zero
This is a run-time error.

2. (+ 3 (sin 0) (+ 3 3))

   9
   No error.

3. (cos (+ 2 3) (+ 10 (sin 0)))(+ 2 2)

   cos: expects only 1 argument, but found 2
   This is a syntax error.

0.5 Translate each of these functions into Racket:

1. $f(x) = x^2 + 2x + 1$

```
(define (f x)
   (+ (* x x)
      (* 2 x)
      1 ))
```

2. $f(x, y, z) = (x - y)^3 + sin(z - y)^2 + yz$

```
(define (f x y z)
   (+ (expt (- x y) 3)
      (expt (sin (- z y)) 2)
      (* y z)))
```

3. $f = 3 + 5 + 8$

```
(define (f)
  (+ 3 5 8))
```

/it This is not a function! The following error will be produced in Racket: define: expected at least one variable after the function name, but found none

0.6 Evaluate using substitution each of the following Racket snippets:

Let:

```
(define (area w h) (* w h))
(define (tax price) (* price 1.13))
(define (magic a b c) (+ a b (area c c)))
```

1. `(area (area 2 3) (+ 4 2) )`

```
(area (area 2 3) (+ 4 2))
(area (* 2 3) (+ 4 2))
(area 6 (+ 4 2))
(area 6 6)
(* 6 6)
36
```

2. `(* (+ 2 1) (tax (* 2.50 (area 2 2))))`

```
(* (+ 2 1) (tax (* 2.50 (area 2 2))))
(* 3 (tax (* 2.50 (area 2 2))))
(* 3 (tax (* 2.50 (* 2 2))))
(* 3 (tax (* 2.50 4)))
(* 3 (tax 10))
(* 3 (* 10 1.13))
(* 3 11.3)
33.9
```

3. `(magic (area 2 1) (area (area 3 2) 1) (tax (area 1 2)))`

```
(magic (area 2 1) (area (area 3 2) 1) (tax (area 1 2)))
(magic (* 2 1) (area (area 3 2) 1) (tax (area 1 2)))
(magic 2 (area (area 3 2) 1) (tax (area 1 2)))
(magic 2 (area (* 3 2) 1) (tax (area 1 2)))
(magic 2 (area 6 1) (tax (area 1 2)))
(magic 2 (* 6 1) (tax (area 1 2)))
(magic 2 6 (tax (area 1 2)))
(magic 2 6 (tax (* 1 2)))
(magic 2 6 (tax 2))
(magic 2 6 (* 2 1.13))
(magic 2 6 2.26)
```

```
(+ 2 6 (area 2.26 2.26))
(+ 2 6 (* 2.26 2.26))
(+ 2 6 5.10)
13.10
```

0.7 What values in each situation should be constants?

1. The cost per litre of gasoline changes several times a day. The cost depends on the current price of oil, the station markup and the government tax rate.

   The station markup and the government tax rate should be constants because they are unlikely to change frequently. The price of oil fluctuates constantly, so it should not be a constant.

2. The Ideal Gas Law, $PV = nRT$, can tell us how a change in pressure affects temperature, etc. In the equation P is the pressure, V is the volume, n is the number of moles, R is Avogadros number and T is the temperature.

   Only R, Avogadros number, should be a constant.

3. Smart watches and phones offer users the ability to calculate how many calories they are burning by monitoring their heartrate. The formula used for a female is: $C = \frac{(0.4472h - 0.05741w + 0.074a - 20.4022)t}{4.184}$, where h is the average heart rate, w is the users weiht, a is the users age and t is the exericise duration. (Source: livewell.jillianmichaels.com/estimate-calories-burned-heart-rate-4146.html).

   The five numerical values should be constants. If the watch or phone program offers users an opportunity to create a personal profile, then weight and age should also be constants. If the calculation is more general, such as a simple web-based calculator, weight and age would not be constants.

0.8 Which of the following are valid constant definitions?

1. `(define (c) (* 3 (expt 10 9)))`
2. `(define kappa 3e10)`
3. `(define cos90degrees (cos (/ pi 2) ))`
4. `(define magic (x y) (cos90degrees))`

Only 2 and 3 are valid.

0.9 Given the following definitions, what does each expression evaluate to?

```
(define a 100)
(define b 200)

(define (magic a x)
    (* (+ a x) a))

(define (magic2 x y b)
    (* (quotient x 51) (remainder y a)))
```

1. `(magic 1 2)`

   3

2. `(magic b 3)`

   40600

3. `(magic (magic2 a b b) a)`

   0

0.10 Write a Racket function for each problem. Use constants when appropriate.

1. Write a function called *compute-tax*, which calculates how much tax is due on the provided price. The tax rate is 13%.

```
(define taxrate 0.13)
(define (compute-tax price)
        (* price taxrate))
```

2. Write a function called *triangle-area*, which calculates the area of a triangle given it's height and base.

```
(define (triangle-area height base)
        (/ (* height base) 2))
```

3. Write a function called *luminosity*, which calculates the apparent brightness of a pixel given by red, green and blue values. The luminosity equation is $L = 0.33r + 0.5g + 0.16b$.

```
(define redConst 0.33)
(define greenConst 0.5)
(define blueConst 0.16)

(define (luminosity r g b)
        (+ (* redConst r)
           (* greenConst g)
           (* blueConst b)))
```

0.11 Why is it important to use constants?

- readability
- reduces errors, i.e. typos
- simplifies value changes, i.e. someone discovers $\pi = 3$

0.12 What does this Racket code do?

```
(define a 1)(define aa
(+ a 1))(define aaa (+
aa a))(define aaaa (+
aaa a))(define (A aA
Aa AA)(/ (+ (* -1 Aa)
(sqrt (- (* Aa Aa)(*
aaaa aA AA))))(* aa aA)))
```

This is an example of obfuscated code. It is very difficult to read and understand. If you wrote this snippet of code, would you remember what it does next week? How could you debug it, or make changes to it? How could another software developer read and understand it? Could they make changes to it? Could they find bugs in it?

It is very important to write readable code. Many companies develop Style Guides which tell developers what their code should look like, how it should be indented, how variables should be named, etc. CS 135 has a Style Guide. Be sure to read and use it! Write readable code.