Question 1. Define a function \texttt{inRegion :: Region -> Bitmap} that transforms a region into the corresponding bitmap.

You may use the function \texttt{inShape :: Shape -> Bitmap}, available from the course web page, that transforms a shape into the corresponding bitmap.

\[30 \text{ marks}\]

Question 2. Define a function \texttt{sunFlower :: Int -> Float -> Region} such that the region \texttt{sunFlower l r} looks like a sun flower with \( l \) leaves and radius \( r \).

Take a picture of a sunflower using the functions defined in Coursework 3.

\[30 \text{ marks}\]

Question 3. Consider the following definitions.

\[
(\cdot) :: [a] \rightarrow [a] \rightarrow [a] \\
[] \quad ++ \quad ys \quad = \quad ys \\
(x:xs) \quad ++ \quad ys \quad = \quad x \quad : \quad (xs \quad ++ \quad ys)
\]

\[
\text{reverse} :: [a] \rightarrow [a] \\
\text{reverse} \quad [] \quad = \quad [] \\
\text{reverse} \quad (x \quad : \quad xs) \quad = \quad \text{reverse} \quad xs \quad ++ \quad [x]
\]

Prove by induction on lists \( \text{reverse} \quad (xs \quad ++ \quad ys) \quad = \quad \text{reverse} \quad ys \quad ++ \quad \text{reverse} \quad xs. \)

\[40 \text{ marks}\]

\text{p.t.o.} \iff
Question 4. The Sierpinski Triangle is a fractal consisting of smaller and smaller rectangular triangles. It is defined recursively as follows: Let a size \( d \) (a floating point number) and a point \( p = (x, y) \) be given. The Sierpinski Triangle of size \( d \) at point \( p \) consists of the rectangular triangle with vertices \( p_1, p_2, p_3 \) together with the three Sierpinski Triangles of size \( d' \) at the points \( p, p_1, p_2 \), where \( d' = d/2 \), \( p_1 = (x + d', y) \), \( p_2 = (x, y + d') \) and \( p_3 = (x + d', y + d') \).

Define a function \( \text{sierpinski} :: \text{Float} \to \text{Float} \to \text{Pt} \to \text{Region} \) such that the region \( \text{sierpinski} s d p \) is an approximation of the Sierpinski Triangle of size \( d \) at point \( p \) where the recursion stops when \( d < s \).

Take a picture of a Sierpinski Triangle using the functions defined in Coursework 3.

Question 5. Consider the following definitions.

\[
\begin{align*}
\text{map} &:: (a \to b) \to [a] \to [b] \\
\text{map} f [] & = [] \\
\text{map} f (x:x:xs) & = f x : \text{map} f xs \\
(\cdot) &:: (b \to c) \to (a \to b) \to a \to c \\
(f \cdot g) x & = f (g x)
\end{align*}
\]

Prove by induction on lists \( \text{map} (f \cdot g) xs = \text{map} f (\text{map} g xs) \).

CS-221 students submit Questions 1 - 3.

CS-M36 students submit Questions 1 - 5.

Submission: Please follow the same rules as for Coursework 2, that is, submit solutions to programming questions by email and solutions to proving questions on paper.

Due date (for CS-221 and CS-M36 students): Tuesday, 12 December 2006.