QUESTION 1.  [5 MARKS]

How does the production of smaller computer circuits increase the speed of computation? What difficulties does this process of miniaturization face?

Solution: Smaller components mean shorter distances for electrical signals to travel, increasing the speed of computation. There is a limit to how closely you can pack tiny components due to (a) the need to dissipate heat, which increases with the number of components, and (b) the limits to how finely the details of the circuit can be resolved using photolithography.

QUESTION 2.  [5 MARKS]

How does your (user's) view of the file flypaper.html differ from the way the same file is stored on a hard drive?

Solution: I either see the HTML code as characters from the ASCII character set (letters from the Latin alphabet, punctuation, numbers) (if I use scite), or else I see fonts and an image rendered by a browser such as firefox. The same file is stored on one or more (not necessarily adjacent) sectors of the hard drive as magnetic dipoles (which take two values).

QUESTION 3.  [29 MARKS]

Explain as much as you can of what's going on in the following Scheme expressions.

Part (A)  [4 MARKS]

(+ (/ (* 3 7) (- 10 4)) 3)

Solution: 3 and 7 are multiplied, producing 21. 4 is subtracted from 10, producing 6. Then 21 is divided by 6, producing 3.5. Finally 3.5 is added to 3, producing 6.5.

Part (B)  [9 MARKS]

(define myList (list 1 3 5 7 9))
(length (append (list (first myList)) (rest (reverse (rest myList)))))

Solution: The list of the first 5 positive odd numbers is produced and labelled by myList. Then a list is made of the first element of myList, namely the list (list 1), the rest of myList is reversed, producing the list (list 9 7 5 3), and then the rest of this is taken, producing the list (list 7 5 3). Finally, the list (list 1) is appended to the list (list 7 5 3), producing the list (list 1 7 5 3), and the length of this list is produced.
PART (C) [6 MARKS]

(define (classify yourList)
  (cond
    (> (length yourList) 100) "long"
    (< (length yourList) 10) "short"
    (else "medium")))

SOLUTION: The procedure classify is being defined, with a parameter yourList. If yourList has more than 100 elements, “long” is produced. Otherwise, if yourList has fewer than 10 elements, “short” is produced. Otherwise “medium” is produced. (classify (list 1 2 3 4 5 6 7 8 9 10 11)) produces “medium” since that list has fewer than 101 and more than 9 elements.

PART (D) [10 MARKS]

(define (listDouble numList)
  (if (empty? numList) empty
      (append (list (* 2 (first numList))) (listDouble (rest numList))))
  (listDouble (list 1 2 3 4 5)))

SOLUTION: The procedure listDouble is being defined, with a parameter numList. If numList is empty, an empty list is produced. Otherwise, append a list containing double the first element of numList to the list produced by applying listDouble to the rest of numList. In effect, a list with every element of numList is produced. In particular, (listDouble (list 1 2 3 4 5)) produces the list (list 2 4 6 8 10).

QUESTION 4. [5 MARKS]

Find a list of positive whole numbers that

1. Add up to 14.
2. Have the largest product (when you multiply together all the numbers in the list) of all possible lists of positive numbers that add up to 14.

Explain how you know your answer is correct.

SOLUTION: The list (3, 3, 3, 3, 2) has the largest product, 162, among all lists of positive numbers that sum to 14. The reason this is true is that

1. We can ignore lists that include a 1, since any such list must include at least one other number, adding 1 to that number increases the product of the list.
2. We can ignore lists that include numbers larger than 3, since any number $n > 3$ can be broken down into 2 and $n - 2$, and the product $n(n - 2)$ will be at least as big as $n$ so long as $n - 2$ is at least $n/2$, which is true for all whole numbers bigger than 3.
3. We can ignore lists that have 3 or more 2s, since we can convert three 2s (contributing 8 to the product) to two 3s (contributing 9 to the product).
These three observations tell me that my list consists of 2s and 3s, with at most two 2s. Things don't work out if I use two 2s (14 - 4 is not divisible by 3), but they do work out if I use one 2 and four 3s, so this must be the answer.