Question 1

(a) Human hair diameter is: 25 micrometer = 25 x 10^{-6} meter
(b) Silicon atom diameter is: 220 ppm = 0.22 x 10^{-9} meter
(c) Size of smallest feature in silicon chips: 50nm = 50 x 10^{-9} meter

1 meter = 39.4 inch
Size of silicon atom in inches = $0.22 \times 10^{-9} \times 39.4$ = 8.668x10-9 inch
The area of a single silicon atom = $(8.668 \times 10^{-9})^2 = 75.134 \times 10^{-18}$ $inch^2$
Possible number of atoms in 1 $inch^2$: $1/(75.134 \times 10^{-18}) = 13.49 \times 10^{15}$ atoms
Current number of transistors in 1 $inch^2$: 10^9 transistors
Ratio of max to current: 13.49×10^6

We calculate how many times it should double to reach the maximum amount:

$2^x = 13.49 \times 10^6$
$x = \log_2 (13.49 \times 10^6) = 23.65$ times

Since each doubling happens every 18 months, the required years:

23.65 x (18/12) = 35.4 years.

Question 2

(1) There are Chinese characters that help builders.
(2) Contains a microprocessor.
(3) There are six colored wires inside iPod remote.

Question 3-4

The saw-tooth pattern is typical of TCP when faced with congestion. TCP will back off its transmission rate if it sees packets are being dropped. It then starts ramping up transmission again slowly. When the congestion happens and the packets are lost, the TCP will cut its transmission rate sharply. But when there is no congestion, TCP will try to increase the transmission rate slowly, until congestion happens again and the packets are dropped. Then the same cycle happens again. That is why we see a slow increase then a sharp decrease, repeated many times in the figure.

The next figure is given by a UDP and a TCP connection sharing the same bandwidth. UDP does not do back-off, which is why it dominates the queue. TCP is still performing back-off and ramp up, but cannot rise as in the previous figure because the UDP flow does not allow it to increase its sending rate since packet loss happens very frequently. Both occur in the Internet, because not all applications use TCP to ensure reliable packet delivery, and they aim to get as much out of the router capacity as they can. Today some routers can apply QoS (Quality of Service) guarantees for some flows so that they get some service guarantees so that not a few flows dominate the router capacity.

Question 5

A microprocessor is basically a synchronous circuit. Suppose a microprocessor fits into a certain area of silicon today. Moore's Law ensures that within 18 months, the same microprocessor fits into a much a smaller piece of silicon. Hence the propagation delay of the circuit is reduced, and so the clock speed of the circuit may be increased.

Question 6

In order for a problem to be in NP, it should be verifiable, given a satisfying assignment, in polynomial time. The formula satisfiability problem is in NP since given satisfying boolean assignments to the variables, we can verify a specific formula in polynomial time. In order to prove the un-satisfiability problem is in NP, we have to find a certificate that enables us to verify the formula is not satisfiable in polynomial time. We cannot use a single assignment to the variables as we did in satisfiability problem, because then we have to verify not only one, but all possible cases that they make the formula evaluate to false. We do not know is such a certificate, but we cannot conclude that it does not exists, therefore the answer is it is not known. In general, it is still an open question whether NP is equal to co-NP, that is, the complement of NP.

Question 7

I would ask my friend to hold out both socks. I claim that one sock is green, and she remembers in which hand that sock is. Then, out of my view, she flips a coin and if it lands heads she interchanges the socks, otherwise she keeps them in the same hand. She presents them to me again, and again I tell her which sock is green. Since she knows whether or not she interchanged the socks, she can check whether my new assertion is consistent with my previous assertion. If I the socks indeed have different colors then I will always answer consistently. But if the socks have the same color then I will error with probability 1/2. Repeating this experiment 100 times, if I am lying then I fool her with probability only 1/2100.