COS 116
The Computational Universe
Final Exam Solutions

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1. Positives: the definition does not depend on physical aspects of how the machine is implemented (i.e. it is "black box"). There is no obvious way to use brute force to cheat. The test cannot be reduced to a formula.

   Negatives: it is anthropomorphic (only tests "human" intelligence). Only tests conversational intelligence (vs. spatial, mathematical, etc.). The test results will always be subjective.

2. 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.

3. The computer simulates the weather by dividing space into a grid, and setting initial conditions for various parameters in each box of the grid. Then it divides time into small slices, and uses the laws of physics (fluid mechanics, thermodynamics, etc.) to compute what the system looks like at the next time step. There are two sources of error in the computation (i) the initial conditions are not precisely known. (ii) we have discretized space and time, which are continuous quantitities. Thus the result of the simulation may be relatively accurate for the near future, but diverges from reality at some point. More computation power may reduce the error from (ii) but will not eliminate error from (i).

   This general idea cannot be currently used to simulate the brain because we do not understand the rules that govern the brain well enough (i.e. the chemistry of neurons, their interconnection structure, the particular thresholds of firing).

4. 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 err with probability ½. Repeating this experiment 100 times, if I am lying then I fool her with probability only $1/2^{100}$.

5. Behaviorism is a theory of how human or animal behavior is determined. It treats the human/animal as a "black box" that learns to react to stimuli based upon whether it

received positive or negative reinforcement (reward or punishment) with this stimulus. The typical example is that of Pavlov's dog, where a dog is conditioned to salivate upon hearing a bell. Behaviorism does not help us develop machine learning algorithms because the animal is viewed as a black box, and there is no statement of how the animal sorts through the world around it to understand what is reward and what is punishment. (In other words, behaviorism assumes a fairly sophisticated black box inside the animal.)

6. (a) TCP numbers the packets so that the receiver can put packets back in order. TCP has an acknowledgement and retransmission mechanism, so if the receiver does not ACK a packet the sender will retransmit. TCP is also a connection-oriented protocol, so if the connection times out the sender may choose to re-establish the connection.

   (b) 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. The back-off is multiplicative (say by a factor of 2), whereas the ramp-up is additive, which gives rise to the saw-tooth pattern.

   (c) This 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, which is why there is a little saw-tooth pattern. Both occur because for some applications (e.g. streaming media) we want to get the data across as fast as possible, without caring about loss, whereas with other applications (e.g. file transfer) we can sacrifice some speed for increased reliability and data integrity.

7. A bot net is a network of "zombie" computers, i.e. a network of computers remotely controlled by an attacker. Bot nets are usually created by a worm or virus that is written for that purpose by an attacker. Instead of wiping out data or causing some other visible damage, the virus or worm installs a secret program that allows the attacker to control the computer remotely. Bot nets can be used for distributed denial of service (DDOS) attacks, and for sending spam.

8. The first program prints "1", then "1" again, and so on, forever. This program never halts. The second program prints "2", then "4", then "16", then "256", and then halts.

9. (a) (0.97 x 20 GB/s) + (0.029 x 4 GB/s) + (0.001 x 1 GB/s) = 19.517 GB/s
   (b) ($500 x 1) + ($1 x 500) + ($1 x 100) = $1100

10. (a)

Current State 1	Current State 2	Input	Next State 1	Next State 2
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	1	1
1	0	0	1	0
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

(b)