• Solve each problem completely, showing each step. Each successful step shown can be awarded partial credit. For example, **write down the definition before doing the math.**

• Feel free to use extra sheets to answer any question. Include these extra sheets with the exam booklet and label each sheet with your name.

• For clarity, copy your final answer to the box after the question. (Explanations do not need to be copied.)

• There is no partial credit on multiple choice questions – so there’s no need to show your work.

• You will have 60 minutes for this exam.

• You may have your portfolio (written homework / example problem descriptions and work).

• THIS IS THE 6325 EXAM, not the 5325 exam.

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Figure 3.6  The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.
Figure 3.7 The Erlang C chart showing the probability of a call being delayed as a function of the number of channels and traffic intensity in Erlangs.
1. (25 pts total) *S/I for a one-dimensional cellular system*: Consider a cellular system deployed along an infinitely long linear highway with all traffic coming from users in vehicles driving on the highway, as shown in the figure. Assume BS towers serve a circular cell with radius $R$ meters, and so BSes are located every $2R$ meters along the highway. Assume that every $N$th BS reuses a channel group, where $N$ is the frequency reuse ratio. Assuming received power is proportional to $1/d^n$ for distance $d$, derive an expression for the signal to co-channel interference (S/I) ratio for a mobile on the edge of a base station’s coverage area, as a function of $N$ and $n$. 

![Diagram of a one-dimensional cellular system]
2. (30 pts total) Consider a blocked-calls-delayed system with a desired probability of delay of 0.02. You have 10 MHz for forward channels and for each 120 kHz of spectrum, you can have 5 channels. Users are assumed to have average holding time 2 minutes, and make 5 calls per hour. Based on the S/I requirements and path loss exponent, you can either use omni antennas with frequency reuse factor $N = 12$, or 120 degree sector antennas with $N = 7$. There are 100 cells in the city-wide deployment.

(a) In the omni case, how many total users (city-wide) can be accommodated?

(b) In the sectoring case, how many total users (city-wide) can be accommodated?

(c) In the omni case, what is $P[\text{delay} > 10 \text{ seconds}]$?
3. (30 pts total) Consider a police radio system operating citywide using one base station, on the public safety band at 705 MHz. Both uplink and downlink use a modulation that requires an SNR of 11.8 dB, and has bandwidth 30 kHz.

- **Base station**: Has transmit power up to 350 W, and an omnidirectional antenna with gain of 7 dBi. The BS receiver has noise figure of 3.0 dB.
- **Police radio**: A police radio has noise figure of 7.0 dB, uses a half-wave dipole antenna, and has maximum transmit power of 2 W.
- **Propagation**: The path loss is given by the log-distance model with reference distance 10 m, and path loss exponent 3.1 beyond 10 m. Because of the safety nature of the system, it must operate during rain and snow, which causes an additional 4 dB loss, and inside of buildings, which cause an additional 20 dB loss.

(a) What is the range of the uplink when the police radio is transmitting at its maximum power?
4. (15 pts) Which of the following will reduce the probability of delay in a blocked-calls delayed system? (Circle all that apply)

   (a) Buy more bandwidth / add more channels
   (b) Replace more macrocells with microcells
   (c) Increase the frequency reuse factor $N$
   (d) Use umbrella cells
   (e) Use repeaters