Topics for Test #2, ISyE 6644 Online Masters in Analytics, Summer 2019

1. I've tried my best to make this list as complete as possible, but I may have missed a topic or two. That being said, you are responsible for everything that we did in class or homework.
2. As GT students, you are expected to formulate problems and solution strategies which are more than mere rote regurgitation of material you learned in class. Thus, you shouldn't be surprised if some questions cover natural extensions of material from class.
3. I'll supply all necessary tables, e.g., N(0,1), t, and χ^2, but you can feel free to use your own.
4. Summary: You'll be responsible for everything up to the continuous version of the Acceptance-Rejection method (Week 7 / HW 7); see below.
5. Study Hint: The material from Test 1 will receive less emphasis than the more-recent stuff; see Practice Test 2.

OK, so off we go! Here's the list of all of the stuff we've done so far (don't be scared!)…

1. **Intro Material**
   a. Definition of simulation
   b. Advantages and disadvantages of simulation
   c. History of simulation
   d. Typical questions and applications

2. **Calculus, Probability, and Statistics Review**
   a. **Calculus [not really responsible for this material, except I might make you search for a zero]**
      i. Basic definitions
      ii. Derivatives
      iii. Solving for zeros
      iv. Integration
      v. Numerical integration
   b. Probability Preliminaries
      i. Conditional probability
      ii. Independent events
      iii. Definition of random variable
      iv. Discrete RV's and probability mass function
      v. Continuous RV's and probability density function
      vi. Cumulative distribution function
   c. Simulating RV's (first pass)
      i. Discrete uniform distribution
      ii. General discrete distribution

iii. Inverse Transform Theorem for continuous RV's
iv. Exponential (and other) continuous distributions via IVT.
v. Generating U(0,1)'s via desert island algorithm, including walk-through of pseudo-code.

d. Expected Values
i. Definition
ii. Discrete and continuous examples of expected value
iii. Law of the Unconscious Statistician
iv. Moments, central moments, variance, standard deviation
v. Discrete and continuous examples of LOTUS
vi. Moment generating function
vii. Examples and properties of mgf's

e. Functions of a RV
i. Discrete examples
ii. Continuous examples
iii. IVT methods (again) with examples
iv. Relationship with LOTUS

f. Jointly distributed RV's
i. Definition of joint cdf
ii. Marginal cdf's
iii. Joint and marginal pmf's
iv. Joint and marginal pdf's
v. Examples for discrete and continuous cases
vi. Independent RV's
vii. Conditional pmf's and pdf's
viii. **Conditional expectation [this won't be on the test]**
ix. **Double expectation E(E(Y|X)) = EY, including examples [this won't be on the test]**

g. Covariance and correlation
i. Definitions
ii. Relationship between independence and correlation
iii. Examples
iv. Miscellaneous properties (e.g., Var(X+Y), bounds on correlation, etc.)

h. Probability distributions
i. Discrete distributions
1. Bernoulli
2. Binomial
3. Geometric
4. Poisson (including discussion on Poisson processes)
ii. Continuous distributions
1. Uniform

2. Exponential (including memoryless property)
3. Erlang, Gamma distributions
4. Triangular
5. Normal (including Standard Normal)
6. Other sampling distributions (including chi-square, t, F, and various relationships with each other)

i. Limit theorems
   i. Linear combinations of independent normal (including distribution of sample mean)
   ii. Convergence in distribution
   iii. Law of Large Numbers
   iv. Central Limit Theorem for independent and identically distributed data.
   v. Examples

j. Statistics Tidbits **[don't worry about this stuff… until Test 3!!! ☺]**
   i. Properties of sample mean and sample variance
   ii. Confidence intervals for the mean and variance

3. Hand Simulations

a. Monte Carlo integration
b. Determining π via simulation (dart tossing on a circle and sphere)
c. Single-server queue (including FIFO and LIFO service disciplines)
d. (s,S) inventory system
e. Simulating RV's (repeats some material from the Prob/Stats review)
f. Spreadsheet simulation (e.g., stock portfolio in Excel)

4. General Simulation Principles

a. Steps in a simulation study
b. List of various simulation definitions (e.g., event, system state, simulation clock, etc.)
c. Event-Scheduling vs. Process Interaction modeling approaches
d. How are events processed?
e. Future events list + extended example
f. Simulation languages – what to look for

5. Arena

a. Layout of Arena screen (panels, modules, etc.)
b. Basic Process template: CREATE-PROCESS-DISPOSE modules
c. SEIZE-DELAY-RELEASE inside of the PROCESS module.
d. Resource, Schedule, Queue, Entity, and other spreadsheets
e. ASSIGN module
f. DECIDE module – probabilistic and conditional routing
g. Simple examples, e.g. (partial list),

i. Single-server queue
ii. Parallel servers
iii. Schedules for servers
iv. Multiple arrival streams

h. Displays, graphics, etc.
i. BATCH and SEPARATE modules
j. Run set-up and control
k. More-sophisticated queueing networks (e.g., two-channel manufacturing example, call center example)
    i. Advanced Process modules (e.g., SEIZE, DELAY, RELEASE modules)
    ii. Some primitive blocks (e.g., QUEUE)
    iii. Use of "pretend" customers
    iv. Nonhomogeneous Poisson arrivals
    v. Use of resource sets, including how to prioritize servers
    vi. Use of submodels
l. Inventory processes
m. **Crazy examples such as re-entrant queues [this won't be on the test]**
n. **SMARTS files and other Rockwell examples [this won't be on the test]**
o. Manufacturing systems **(you're only responsible for the basics)**
    i. Advanced Transfer modules
    ii. Sequences of customer visitation locations
    iii. **Advanced sets of sequences [this won't be on the test]**

6. **Uniform Random Number Generation**
    a. Overview – desirable properties of a pseudo-random number generator
    b. Some generators we won't use, e.g.,
        i. PRN's from tables
        ii. Midsquare
    c. Linear congruential generators
        i. Cycling
        ii. 16807 desert island generator (again)
        iii. RANDU (a bad generator)
    d. Tausworthe generator
    e. Combined generators
        i. L'Ecuyer's generator of cycle length 2^{191}
        ii. Mersenne Twister
    f. Some theoretical considerations, e.g., from Knuth's book
    g. Statistical tests for randomness
        i. Goodness-of-fit tests
            1. Chi-squared
            2. Kolmorogov-Smirnov

ii. Runs tests for independence
    1. Runs up and down
    2. Runs above and below the mean
    3. **Autocorrelation test [this won't be on the test]**

7. Random Variate Generation

a. Inverse Transform Theorem (yet again)
    i. Proof
    ii. Discrete example adaptations
    iii. Continuous examples
        1. East ones such as Exponential, Weibull, etc.
        2. Slightly harder examples such as Triangle distribution
        3. Normal distribution, both exact and approximate methods
    iv. Special case methods, e.g., Geometric
    v. **Empirical distributions [this won't be on the test]**
b. Convolution method
    i. Binomial
    ii. Triangle
    iii. Erlang
    iv. CLT
        1. Desert island sum of Uniforms to generate Normal
        2. Normal approximation to Poisson (including continuity correction)
    v. Cauchy
        1. Cauchy's add up to another Cauchy
        2. IVT method
        3. Ratio of two Normals
c. Acceptance-Rejection methods
    i. Trivial Uniform example
    ii. Some discussion on general method
    iii. **Proof of the general method [don't expect to see this on the final, unless I'm in a really bad mood!]**
    iv. Examples involving polynomial and half-normal (continuous distribution) p.d.f.'s
    v. **Poisson distribution [not on this test… stay tuned for Test 3!]**