

# ECE 510 Midterm – 13 Feb 2013

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## Questions (short answer)

1. What does QRE stand for?
2. Name 3 job activities a QRE might perform.
3. Would 100 DPM at the end of an expected life of 5 years be a typical goal for a semiconductor component sold into a consumer market? Give at least one reason why or why not.
4. What was the fail mechanism and the associated stress that caused the failure and crash of the De Havilland Comet aircraft in the 1950's?
5. Name two fail mechanisms for commercial semiconductor devices and one associated stress for each.
6. Histograms and CDF plots are both useful ways of looking at data. Name one disadvantage of a histogram and the corresponding advantage of a CDF plot.
7. Consider the CDF plot for a set of  $N$  data points with values  $x_i$ . Each data point is plotted. Give the x (horizontal) and y (vertical) position of point  $i$ . That is, what goes on the x and y axes of a CDF plot?

8. Describe the distinction between a sample statistic and a population parameter.

## Problems

Please show your work or describe your thinking for each problem; usually a single sentence is all that is needed.

1. If 0.7% of a population of parts are faulty when shipped from a factory, what is the DPM of the population? Is this a measure of quality or reliability?

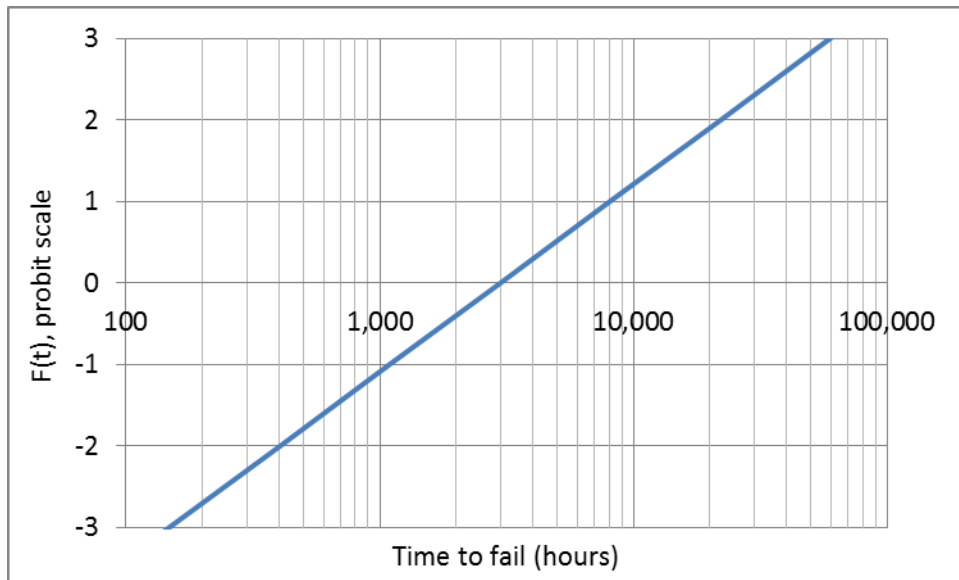
2. If 0.7% of a population of parts fails in its first 10,000 hours of operation, what is the FIT rate for the population? Is this a measure of quality or reliability?

3. Say that you did a Monte Carlo simulation of some sort that used  $N=10,000$  randomly generated data points. If your boss tells you that she wants 10x greater Monte Carlo accuracy (that is, 1/10 of the random Monte Carlo uncertainty than your current simulation), what sample size would you need to use?

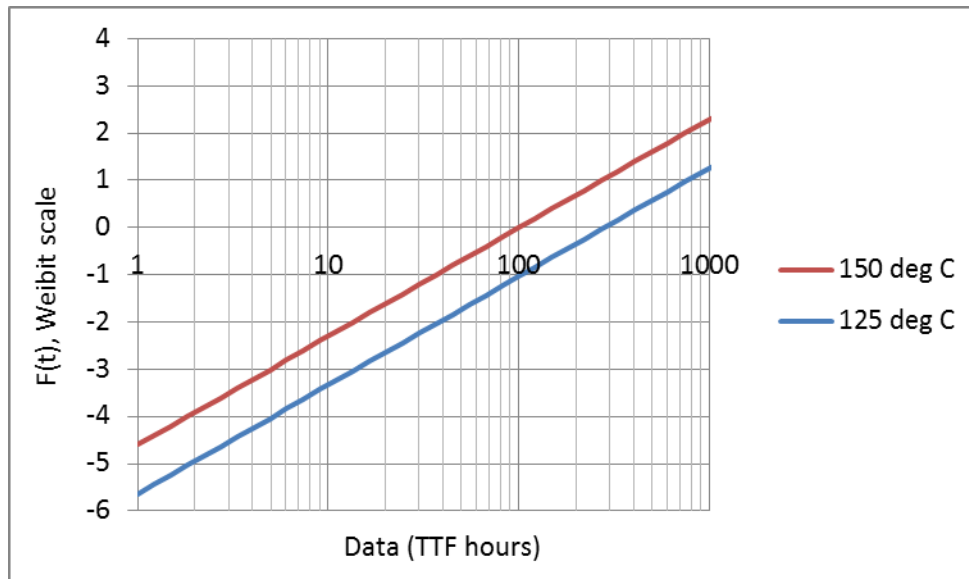
4. Say that a fail mechanism has a hazard function  $h(t) = 1$  FIT (that is, constant at 1 FIT). (a) What is the corresponding fail function  $F(t)$ ? Give the value of any parameters in  $F(t)$ , including units. (b) What is the MTTF? (c) What is the probability of failure in 10 years of use?

5. How many samples do we need to verify that a population has a MTTF of 100,000 hours or more at 90% confidence, given that we can run the test for 1000 hours and no fails are allowed?

6. Consider the cumulative fail function  $F(t)$  shown in the graph below. Note that the time axis is on a log scale but is labeled in actual (non-log) time. (a) What functional form is this? (b) What are the values of the parameters for this function? Please include units on your parameter values. Your values should be correct to within 10% of the true values.



7. Consider the two cumulative fail functions shown in the graph below for the same population of devices tested at two different temperatures. Note that the time axis is on a log scale but is labeled in actual (non-log) time. (a) Assuming a Weibull distribution, find the alpha (scale) and beta (shape) parameters for the 150 deg C line. (b) Is acceleration valid for this data set? Why or why not? (c) Find the acceleration factor from 125 deg C to 150 deg C. (d) Find the activation energy  $E_a$  in an Arrhenius acceleration model for this mechanism. Your values should be within 10% of the correct answer.



## Spreadsheet problems

Show work and thought process on spreadsheet or here (or both).

1. Fit this distribution by eye. (a) Make a Weibit plot of the TTF data. (b) Construct a 2-Weibull  $F(t)$  model, plot the model on same graph as the data, and fit the model to the data "by eye" (using your judgment on best fit). (c) Is this an example of the bathtub curve, with an infant mortality mechanism and a wearout mechanism?
2. Determine the functional form of this distribution data. Make "exbit", Weibit, probit (normal), and lognormal plots of the data and determine "by eye" which fit is the best.
3. A development group did an experiment and measured the TTF for all 10 units in their sample, and fit the data to a Weibull distribution with  $\alpha=100$  hours and  $\beta=1.5$ . They have asked you to find the 90% two-sided confidence limits on their  $\alpha$  and  $\beta$  parameters. Use a Monte Carlo simulation method to find the UCL and LCL for each parameter separately (don't consider any correlations).  
  
To do this, simulate 100 data sets, one simulation per row, and determine the  $\alpha$  and  $\beta$  parameters for each. (That is, calculate the Weibit and  $\ln(\text{time})$  for each synthesized data row, and use the graphical (slope and intercept) method to find  $\beta$  and  $\alpha$  for each row.) Then use the resulting distribution of  $\alpha$ s and  $\beta$ s to find the confidence limits.
4. Fit the given Weibull readout data with voltage acceleration. The data below is from a 2-leg, 6-readout experiment, where leg1 was stressed at 1.2V and leg2 was stressed at 1.4V. Each leg had the same readout times; at each readout, the number of fails was measured. We want to fit the data with a Weibull model and an exponential voltage acceleration model. Use the method of maximum likelihood to find the best estimate for the Weibull and acceleration parameters. Then use the likelihood ratio method to find the 90% two-sided confidence limits (UCL and LCL) on the  $C$  parameter only.