Exam II
Administered: Friday, October 10, 2014
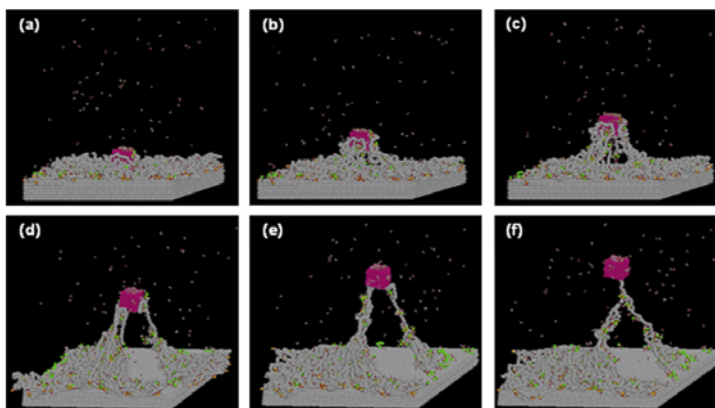22 points

For each problem part: 0 points if not attempted or no work shown,
                           1 point for partial credit, if work is shown,
                           2 points for correct numerical value of solution

Problem 1. (16 points)

We are evaluating the energy of adhesion between catalyst nanoparticles and a carbon substrate covered in a polymer film. See attached Figure for snapshots of a molecular dynamics simulation in which the Pt nanoparticle (pink) is detached from the surface. We repeat the simulation 8 times. Due to the variable nature of the polymer bridging that forms during the detachment process, there is significant variation in the simulation repetitions. We obtain the following values for the energy of adhesion.

Snapshots illustrating the process of Pt detachment from the graphite surface coated in a Nafion film for a system includes a 2 nm cubic Pt at the hydration level of $\lambda = 3$ H_2O/SO_3^-.

From: He, Q., Joy, D.C., Keffer, D.J., "Nanoparticle Adhesion in PEM Fuel Cell Electrodes", J. Power Sources 241 2013 pp. 634-646, doi: 10.1016/j.jpowsour.2013.05.011.

Energy of Adhesion (aJ)
-11.44
-11.04
-10.81
-8.34
-10.24
-10.29
-8.95
-11.27

(a) Compute the sample mean.
(b) Compute the sample variance.
(c) What PDF is appropriate for determining a confidence interval on the mean?
(d) Find the lower limit on a 98% confidence interval on the mean.
(e) Find the upper limit on a 98% confidence interval on the mean.
(f) What PDF is appropriate for determining a confidence interval on the variance?
(g) Find the lower limit on a 90% confidence interval on the variance.
(h) Find the upper limit on a 90% confidence interval on the variance.

Problem 2. (6 points)

A smoke detector is powered by four batteries. Each battery has a mean life time of 36 months. The probability distribution describing the lifetime of a single battery is given by the gamma distribution with parameters $\alpha = 36$ and $\beta = 1$. The smoke detector only operates if all four batteries continue to function.
(a) What is the probability that an individual battery is operating after 24 months?
(b) What PDF would describe the probability that all 4 batteries are functioning after 24 months?
(c) What is the probability that the smoke detector still operates after 24 months?