3. A diffusion furnace performs polysilicon depositions on one lot of wafers in one machine cycle. At the start of the machine cycle, the load lock of the furnace is pumped down to vacuum. The load lock to the furnace incorporates an O ring that is subject to failure. When the O ring fails, the whole lot become contaminated and must be thrown out. It is not possible to determine if the O ring has failed until after the machine cycle is completed, at which point it is obvious if the O ring failed or not. When the O ring fails or when it is replaced before failure, we assume zero time required to replace and re-qualify before the next machine cycle. However, the replacement and re-qualification cost $1,000 each time.

   Suppose the furnace works on one specific step of a certain process and the line yield for that process after the furnace step is 95%. The overall die yield of that process is 90%. One 100%-yielding lot of such a process will be sold at an average price of $30,000.

   Data on O ring lifetimes is as follows:

# of furnace cycles, n	fraction that fail in cycle n
1	.00
2	.01
3	.02
4	.04
5	.10

   (a) What is the expected revenue loss for one failure of the O ring?

   (b) What is the average number of cycles between two replacements if it is scheduled to do planned replacement of the O ring after every 5 cycles?

   (c) In order to maximize the total profit, after how many furnace cycles should a planned replacement of the O ring occur?

IEOR 130
Methods of Manufacturing Improvement
Midterm Examination
Spring, 2005
Instructor: Shengwei Ding

Open book and notes. Work all problems. 20 points each problem.

1. The average rework rate for photolithography at a particular fab is 4%. Recent data on the photo rework is as follows.

Shift #	# of wafers processed	# of wafers reworked
1	500	20
2	650	39
3	550	36
4	600	18

   (a) During which shifts was photo rework in statistical control? (Note: use p-chart.)

   (b) Suppose normally 600 wafers are processed in a standard shift. When the number of wafers reworked in such a standard shift is above 36, the mask should be replaced. What is the C_{pk} corresponding to this specification?

   (c) Suppose when the mask becomes dirty, the rework rate increases to 7%. What is the probability of type 2 error with the specification as in (b)?

2. The CVD process engineer must decide which of two possible CVD machines to buy. The machines will be used at two different process steps in the process flow to make an advanced memory device. The machines cost the same. Assume the process time and availability of each kind of machine are identical, but there are significant differences in the yields, as follows.

   The engineer has conducted many test runs and has determined that the expected wafer scrap rate for either step when using machine type 1 is 0.005. The expected wafer scrap rate for either step when using machine type 2 is 0.008. All these wafer scraps will turn out to be line yield losses.

   The tests also reveal that, on average, machine type 1 deposits 0.05 defects per square centimeter per wafer pass, while machine type 2 deposits 0.03 defects per square centimeter per wafer pass. The engineer estimates that for either machine type, 20% of such defects would be fatal.

   (a) Provide a condition on the die area for the memory device such that machine type 1 would be preferred.

   (b) Suppose the die area A = 0.5 sq cm. Upon further investigation, the engineer determines that, while the fraction of particles that are fatal is indeed 20% for machine type 2, it is somewhat higher than 20% for machine type 1. How much higher could it be such that machine type 1 is still the better choice?

   (c) Suppose the defect density was 0.5 defects per square centimeter without considering the defects due to the two CVD machines. Compare Murphy model and Poisson model on calculating the difference of yield?