Solutions to IEOR 130 Midterm Examination
Fall, 2012 Prof. Leachman
Open Notes. Calculators and laptops may be used, but no Internet access. Work all problems. In
In your answers, show all formulas that you apply and the numbers you input to the formulas.
Be sure to write your name (first and last) and SSID in the top right corner of all pages of your answers.

1. A particular manufacturing process has a die yield of 90%. There are two failure mechanisms in the process that lead to die yield loss: particle contamination and mechanical damage. There is a stationary baseline distribution of particle contamination present on every wafer, but there also are occasional "excursions" when particle contamination is excessive. A control chart has been instituted for monitoring particle contamination, and its upper control limit is 220 particles per wafer. Including the impact of particle excursions, the long-run average particle density is 220 particles per wafer. Each wafer is printed with 5,000 die. Assume the space between die is negligible. Assume all particles are fatal to die yield.

(a) Estimate the defect-limited yield of the process. (The defect-limited yield reflects solely the losses due to particle contamination.)

Y_d = EXP {– (expected # of defects per die)} = EXP { – (220/5000)} = 0.9570

(b) What is the mean number of particles per wafer when the process is in statistical control?

$\text{UCL} = c + 3\sqrt{c}$
$220 - c = 3\sqrt{c}$
$220*220 \text{ -}440c + c^2 = 9c$
$220*220 - 449c + c^2 = 0$

$c = [\ 449 \pm \sqrt{449*449 - 4*220*220}\ ] / 2 = [\ 449 \pm \sqrt{201{,}601 - 193{,}600}\ ] / 2 = 180$

(c) Estimate the baseline defect-limited yield. (The baseline defect-limited yield reflects solely the losses due to particle contamination when such contamination is in statistical control.)

Y_r = EXP {– (180/5000)} = 0.9646

(d) Estimate the mechanical-limited yield. (The mechanical-limited yield reflects solely the losses due to mechanical damage.)

$Y_m = Y / Y_d = 0.9/0.9570 = 0.9404$

(e) What is the systematic mechanisms limited yield of the process?

$Y_s = Y / Y_r = 0.9/0.9646 = 0.93303$

(f) Estimate the yield loss due to particle excursions.

$0.9404*0.9646*Y_{pe} = 0.9$

$Y_{pe} = 0.9/(0.9404*0.9646) = 0.9921$

$1-Y_{pe} = 0.0079$, i.e., only 0.79 percentage points of yield loss is attributable to particle excursions.

2. Consider the following failure distribution:

Weeks since PM or repair	Probability of failure in that week
1	0.05
2	0.08
3	0.10
4	0.12
5	0.15
6	0.15
7	0.15
8	0.15
9	0.05

Repair after failure costs \$5,000 plus \$20,000 for ruined product and requires 12 hours. Performance of a PM costs \$3,500 and requires 8 hours. The PM frequency could be set to be weekly, bi-weekly, every 3 weeks, every 4 weeks, every 5 weeks, every 6 weeks, or never.

(a) Based on minimizing the stated costs, what PM frequency is best?

c_1 = \$25,000, c_2 = \$3,500, p_k's are given above. See spreadsheet for calculations of $G(t)$. The best frequency is a PM every 3 weeks.

(b) Based on maximizing machine availability, what PM frequency is best?

$c_1 = 12$, $c_2 = 8$, p_k's are given above. See spreadsheet for calculations of $G(t)$. The best frequency is a PM every 7 weeks, but 6 weeks is the maximum allowed, so we should compare G(6) with no PM and found that every 6 weeks is the best choice.

(c) What additional information should be requested to decide the best PM frequency?

The issues are (1) what impact down time will have on revenue and (2) does yield degrade with prolonged use of the machine or not. Useful information would be: utilization of the machine, availability of the machine, output of the machine, selling price of product, overall yield from machine steps to output, overall yield, and fatal defect density as a function of machine usage. It could be that maximizing profit may lead to a best PM frequency of 3, 4, 5 or 6 weeks.