

CHG3337
CHEMICAL ENGINEERING/GENIE CHIMIQUE
University of Ottawa/Université d'Ottawa

MIDTERM TEST
Professor: Nicholas Burn

Date: November 2, 2005
Duration: 1 hour 20 minutes

Note: One one-sided 8½ x 11 cheat sheet is allowed
A non-programmable calculator is allowed
Read all questions carefully.

Marks

13

QUESTION ONE

In semiconductor fabrication processes, the aluminum metal line width is a key factor in determining the speed of the transistor devices. As a process engineer, you are responsible for ensuring that the line width is well controlled. In order to set specification limits, you conduct a cause-and-effect experiment where you vary the line width at controlled settings and observe the speed of the device after it has been assembled.

<u>Metal Line Width (nanometres)</u>	<u>Speed (micro seconds)</u>
80	25
85	28
90	34
95	37
100	45

You propose to fit the following model, $Y = \beta_0 + \beta_1 X$, to the above data.

A colleague of yours has done some preliminary calculations for you:

$$(\mathbf{X}^T \mathbf{X})^{-1} = \begin{bmatrix} 32.6 & -0.36 \\ -0.36 & 0.004 \end{bmatrix} \quad \mathbf{X}^T \mathbf{Y} = \begin{bmatrix} 169 \\ 15455 \end{bmatrix}$$

- What is the X variable, and what is the Y variable in this problem?
- Using the provided information, estimate the coefficients in the proposed model and write out the fitted model.
- You don't trust that your colleague has performed their calculations correctly. Given that $s_x = 7.906$, $s_y = 7.855$, and $r = 0.986$, calculate estimates for the model coefficients using another approach that also results in linear least squares regression estimates. Was your suspicion of your colleague justified?

[Hint: You need to do some calculations using the raw data above.]

QUESTION FOUR

An experiment was conducted to study the effect of bake temperature and line speed on the pressure required to remove an adhesive tape. The temperature was varied over three levels: 235, 265, and 295 degrees Centigrade. The line speed was also varied over three levels: 25, 40, and 55 feet per minute. The results in terms of coded factor settings were as follows:

Temp	Line Speed	PSI
1	1	15.4
-1	-1	19.1
0	0	18.2
-1	1	13.5
1	-1	18
1	0	20
0	-1	19.4
0	1	14
-1	0	18.5

Excel was used to fit the following proposed full quadratic model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{12} X_1 X_2,$$

where X_1 is the code Temp, and X_2 is the coded Line Speed.

Regression Statistics	
Multiple R	0.982
R Square	0.964
Adj R Square	0.905
Standard Error	0.744
Observations	9

ANOVA					
	df	SS	MS	F	P-value
Regression	5	44.941	8.988	16.233	0.022
Residual	3	1.661	0.554		
Total	8	46.602			

	Coeff	Std. Err.	t Stat	P-value	Lower 95%	Upper 95%
Intercept	18.756	0.555	33.816	0.000	16.990	20.521
Temp	0.383	0.304	1.262	0.296	-0.583	1.350
Line Speed	-2.267	0.304	-7.461	0.005	-3.233	-1.300
Temp^2	0.217	0.526	0.412	0.708	-1.458	1.891
Speed^2	-2.333	0.526	-4.435	0.021	-4.008	-0.659
Temp*Speed	0.750	0.372	2.016	0.137	-0.434	1.934