UNIVERSITY OF JORDAN
CHEMICAL ENGINEERING DEPARTMENT

0905331 –PROCESS MODELING BY STATISTICAL METHODS

Name	
University ID	
Section	

Course	Process modeling by statistical methods (0905331)
Exam	Final
Date	Tuesday, 24/01/2006
Time	120 minutes open book part
Instructor	Dr. Ali Al-matar

Problem	Full Mark	Mark
1	15	
2	10	
3	30	
4	15	
5	30	
Total	**100**	

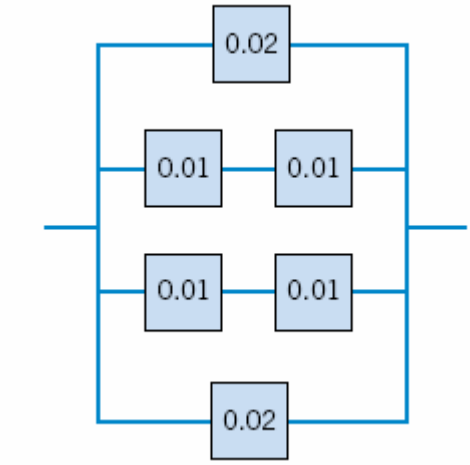
وقع على القسَم التالي المتعلق بالغش الأكاديمي:

اقسم بالله أنني لم اغش في هذا الامتحان ولم أساعد أي شخص على الغش سواءً لمنفعتي الشخصية أو لمنفعة الآخرين، وعلى هذا أوقع.

التوقيع:

Question 1 (15 points)

The following circuit operates if and only if there is a path of functional devices from left to right. Assume that devices fail independently and that the probability of failure of each device is as shown. What is the probability that the circuit does not operate.



Question 2 (10 points)

When a computer manufacturer tests a disk, it writes to the disk and then tests it using a certifier. The certifier counts the number of missing pulses or errors. The number of errors on a test area on a disk has a Poisson distribution with $\lambda = 0.2$.

a) What is the expected number of errors per test area?
b) What percentage of test areas has two or fewer errors?

Question 3 (30 points)

Crystal size distribution for two samples, F01 and F02, of the fine grade crystals produced at the Arab Potash Co. (APC) are given below. The values given in the second and third columns are the cumulative fraction of crystals passing the sieve with the given mesh size.

Crystal size (μm)	F01 (-)	F02 (-)
53	0.00	0.00
75	0.02	0.04
126	0.12	0.15
178	0.25	0.35
252	0.50	0.60
357	0.73	0.78
505	0.88	0.90
714	1.00	1.00
Generally compliant with APC specs, but generated for exam purposes.		

a) Are the values for F01 and F02 a CDF? If your answer is yes, why? If your answer were no, explain why and convert these results into a CDF.

b) Generate the PDF for both F01 and F02.

c) What type of distributions do F01 and F02 represent?

d) Provide a point estimate for the mean crystal size of the population represented by F01.

e) Provide a point estimate for the standard deviation of the crystal size of the population represented by F02.

f) What is the standard error of the sample mean for F01?

g) What is the median crystal size for F01?

h) What is the mode for F02?

Question 4 (15 points)

The crystal size distribution of potash produced using two different processes is being investigated. Two random samples of sizes $n_1 = 8$ and $n_2 = 16$ are selected, and the sample means and sample variances are as given below. Assume that the data are drawn from a normal distribution.

a) Is there evidence to support the claim that the two methods produce potash crystals with different mean sizes? Use $\alpha = 0.05$ in arriving at this conclusion.
b) Find the P-value from the proper statistic you calculated in part a.
c) Construct a 95% confidence interval for the difference in the crystal size. Interpret this interval.

	Sample 1	Sample 2
$\bar{x}$ (μm)	343.8	311.7
s^2 (μm^2)	32,253	31,538
n (-)	8	16

Question 5 (30 points)

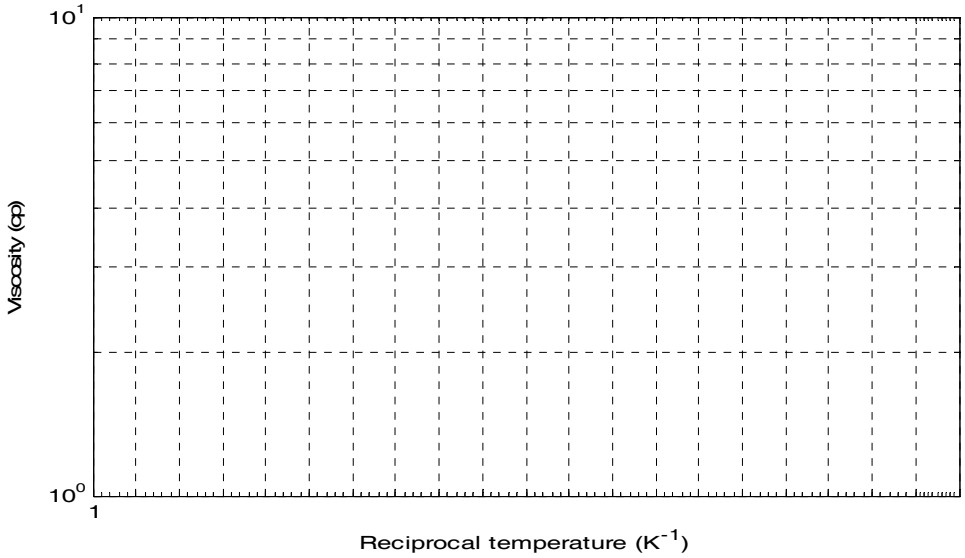
Al-Matar and Rawajfeh (*Ali Al-Matar, and Rawajfeh Khaled, "Uranium extraction from purified wet process Jordanian phosphoric acid: A development study," Hydrometallurgy, 56:309-322, July 2000.)* reported the viscosity of 28% P_2O_5 phosphoric acid produced in Aqaba as a function of temperature. Their data is given below.

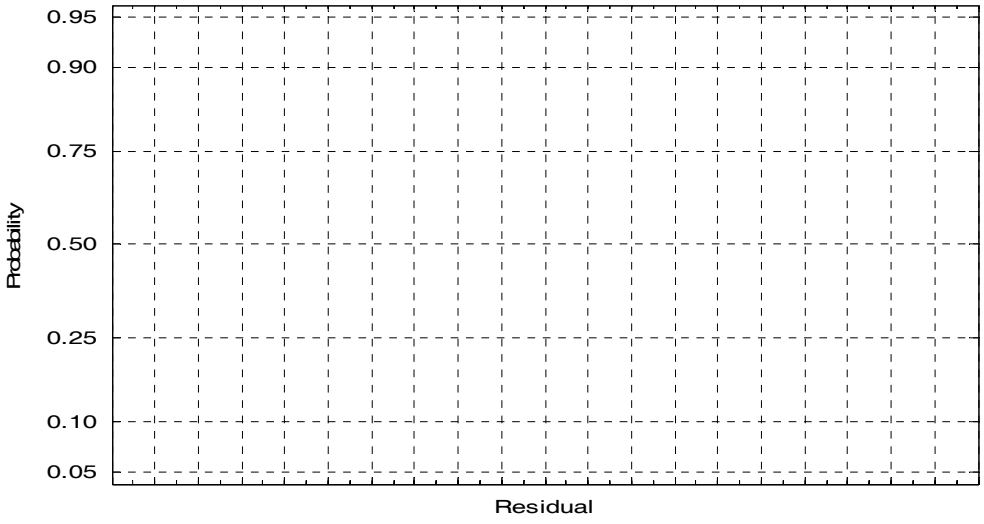
Temperature T (K)	Viscosity μ (mPa.s)
289.35	4.74
293.35	4.48
298.25	4.12
308.15	3.55
313.15	3.22
323.15	3.07

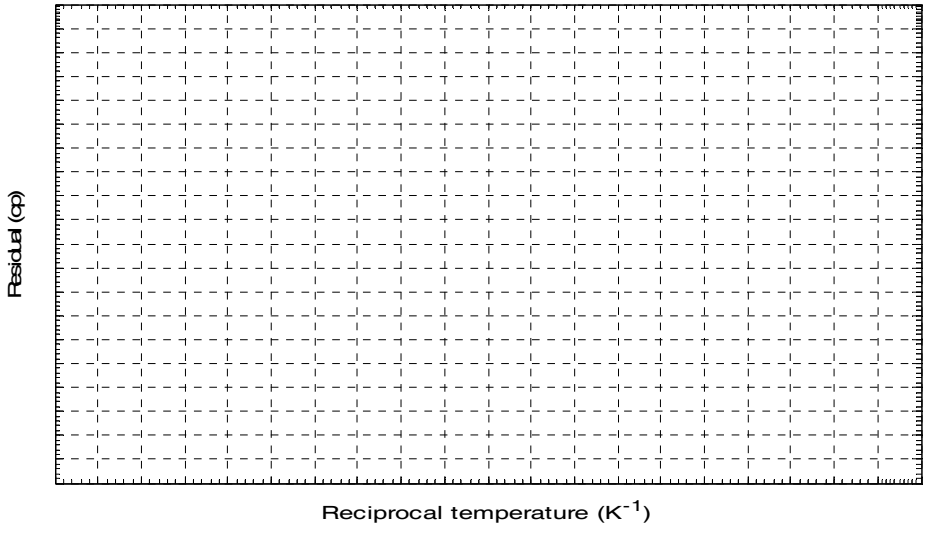
A simple model to describe the dependence of viscosity on temperature is

$$\mu = \beta_0 \exp\left[\frac{\beta_1'}{RT}\right] = \beta_0 \exp\left[\frac{\beta_1}{T}\right]$$

a) Construct a scatter diagram of the data by plotting the linearized form of the equation above. What are the *y* and *x* for the linearized form?
b) Fit a simple linear regression model for the linearized form.
c) Find the confidence intervals for the intercept and slope of the linearized model. Use 95% confidence level.
d) Calculate R^2 and R for the model.
e) Calculate RMSE.
f) Analyze the residuals and comment on model adequacy. The experimental error is estimated to be around 3%.


10^1
10^0
1
Viscosity (cp)
Reciprocal temperature (K^{-1})


0.95
0.90
0.75
0.50
0.25
0.10
0.05
Probability
Residual


Residual (cp)
Reciprocal temperature (K^{-1})