SAMPLE QUESTIONS

1. Two lines are configured to produce 0.75 mm sheet; their historical standard deviations are unknown but are considered equal. The following data was collected to determine if the mean of the machines' output is equal with 95% confidence

Line 1	Line 2
0.752	0.738
0.784	0.763
0.752	0.748
0.756	0.748
0.761	0.754
0.751	0.742
0.764	0.747
0.752	0.759

What is the value of the test statistic, and is the null hypothesis rejected?

(A) 1.86, not rejected
(B) 1.86, rejected
(C) 1.98, not rejected
(D) 1.98, rejected

2. Your company manufactures high-quality steel plate for pressure vessels. You test the material for a variety of physical and chemical properties, and maintain records so that statistical data on the product can be maintained, trends noted and corrective action taken, if required. One of your company's most successful products is low-carbon steel plate used for pressure vessels.

ASTM specification A516 for pressure vessel steel specifies, among other things, the following physical and chemical properties:

Composition, percent, for A516 Grade 60:

For plate 1/2 inch to 2 inches thick

Carbon, max	Silicon	Manganese	Phosphorus, max	Sulfur, max
0.23	0.15 – 0.40	0.85 – 1.20	0.035	0.035

Tensile strength 60-80 ksi (60,000-80,000 lbf/in^2)
Yield strength minimum 32 ksi
Minimum elongation in 2 inches = 25%

In addition, some purchasers require impact testing of the material. A typical requirement is a Charpy test result of minimum 13 foot-pounds force (ft-lbf) energy absorption at -60°F test temperature. This value is to be the average of three specimens, with minimum energy absorption on any one specimen of 10 ft-lbf.

Seven (7) Charpy tests were run on standard samples from a heat of the steel. The test temperature was -60^{o}F. The energy absorption, (ft-lbf) was as follows for the seven samples.

15, 15, 19, 20, 21, 21, 22.

The mean, median, and standard deviation, (ft-lbf) of the data set are respectively:

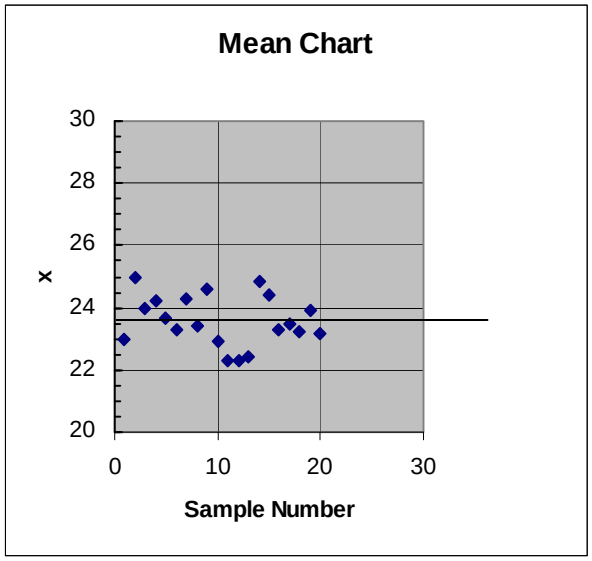
(A) 19, 19, 2.67
(B) 19, 20, 2.67
(C) 19, 20, 7.1
(D) 20, 20, 2.67.

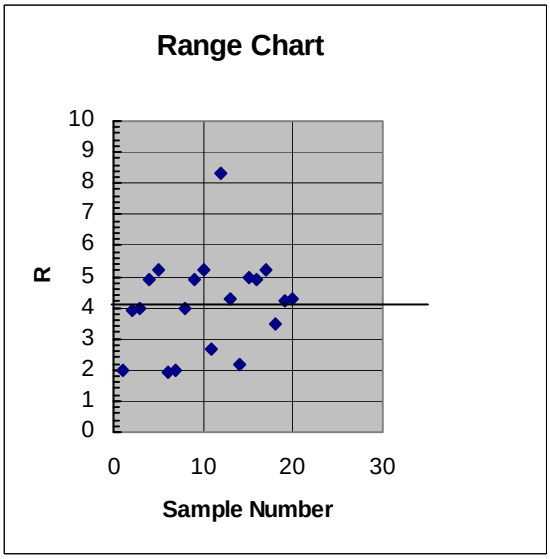
3. The control charts below are for two billet shears for which n=4. Which is (are) in control?

(A) 1
(B) 2
(C) 1 and 2
(D) neither 1 or 2

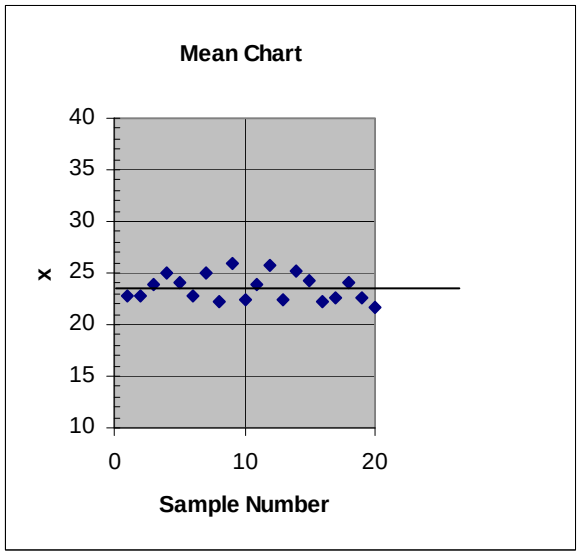
Control Charts

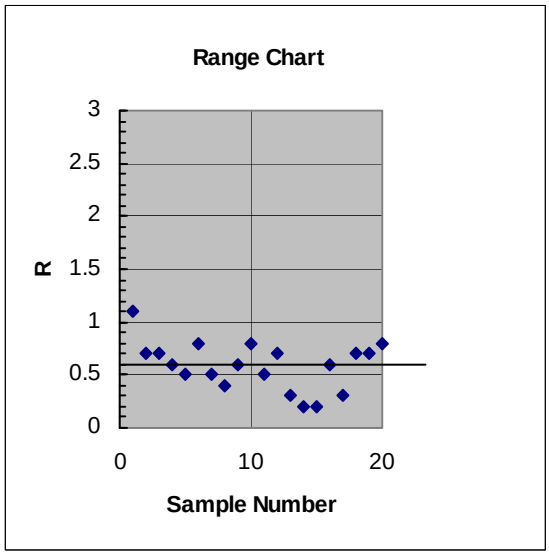
Shear 1





Shear 2





4. A first order, homogeneous liquid phase reaction has a rate constant of 0.2 min^{-1}. A continuous reactor has been built to treat 10 L/min of the reactant (initial concentration of 1 mole/L). The reactor has a volume of 100 L. The reactor was supposed to be perfectly mixed, but you are not sure that it is. A tracer test gave the following data:

Time (min)	0	5	10	15	20	25	30
Conc. (arb)	0	10	4	3	2	1	0

The mean residence time (min) based upon the tracer test is most nearly:

(A) 10
(B) 12.5
(C) 15
(D) 25

5. A cross flow condensing heat exchanger is utilized to heat the pickling solution in a recirculating loop.

Steam properties:
Enthalpy = 745 kcal/kg
Temperature = 175°C
Solution properties:
Flow = 540 m^3/h
Specific heat = 1 kcal/kg.K
Density = 1200 kg/m^3

How much heat exchanger area (m^2) is needed given the following:

U = 0.7 kcal/sec.m^2.K	overall heat transfer coefficient
F= 0.8	heat exchanger orientation efficiency factor
T_{acidin} = 60°C	inlet acid temperature
$T_{acidout}$ = 65°C	outlet acid temperature
T_{steam} = 175°C	condensing steam temperature
Q = 2 x 10^6 kcal/hour	heat load

(A) 5.65
(B) 7.05
(C) 8.35
(D) 8.82

SOLUTIONS/RATIONALE

1. Key is (A). 1.86, not rejected

Distracters:
1.96 is the value calculated if 16 degrees of freedom are used (instead of 14). The critical t-value for this 2-sided t-test with 14 degrees of freedom is 2.145; 1.85<2.145, so the null hypothesis is not rejected.

2. Key is (B) This question tests the candidates' ability to determine a standard deviation from a data set and to understand and apply terms used in statistical evaluations.

Solution. Let X = data values; M = mean of data values, d = deviation of individual data points from the mean, and σ = standard deviation. Let n = number of data points, 7 in this case.

Construct a table as follows:

X	d	d^2
15	-4	16
15	-4	16
19	0	0
20	+1	1
21	+2	4
21	+2	4
22	+3	9

$M = (\Sigma X)/n = 19$

The sum of d's equals zero, as it should. $\Sigma(d^2) = 50$
$\sigma = \sqrt{(d^2/n)} = \sqrt{(50/7)} = 2.67$.

The median is the value where there are as many data points above as below. The median is 20.

Distracters:

(A) Uses 19 as both the mean and the median.
(C) Mean and median represent different things. Forgets to take the square root when calculating the standard deviation.
(D) Uses 20 for both the mean and the median.

3. Key is (A)

Shear 1
- Mean Chart
- UCL = 26.6
- LCL = 20.6

Range Chart
- UCL = 9.46
- LCL = 0

Shear 2
- Mean Chart
- UCL = 23.9
- LCL = 23.1

Range Chart
- UCL = 1.37
- LCL = 0

Distracters:

(B) 2^{nd} mean chart out of control
(C) 2^{nd} mean chart out of control
(D) Both mean & range chart #1 in control

4. Key is (A). The mean residence time $\tau = \Sigma C_i t_i \Delta t_i / \Sigma C_i \Delta t_i =$ $(10x5x5+4x10x5+3x15x5+2x20x5+1x25x5)/(10+4+3+2+1)x5 = 10$ minutes

Distracters:

(B) 25/2 = 12.5 minutes average from 0 to 25 minutes
(C) 30/2 = 15 minutes, average of the table
(D) $\Sigma t_i/n =$ 25 minutes

5. Key is (D) 8.82 m^2
LMTD= ((175-65)-(175-60))/ln((175-65)/(175-60)) = 112.5
A = q/(LMTD*U*F)
A = 2000000/(0.7/3600)/112.5/0.8/= 8.82 m^2

Distracters:

(A) 5.65 m^2
multiplied by F
A = q/(LMTD*U*F)
A = 2000000/(0.7/3600)/112.5*0.8= = 5.65 m^2

(B) 7.05 m^2
Did not include F
A = 2000000/(0.7/3600)/112.5= = 7.05 m^2

(C) 8.35 m^2
LMTD = (175 +(60+65)/2)/2=118.75
A = q/(LMTD*U*F)
A = 2000000/(0.7/3600)/118.75/0.8= = 8.35 m^2