1. [(a)-(f): +2 each, (g)-(j): +2.5 each] For each of the following, select the ***most*** appropriate chart to use.

(a) When I walk my dogs daily, I track the number of times that they stop to sniff a mailbox, bush, another dog, etc.

* Good problem for distinguishing between c and u chart!

Variable Chart   *p* or *np*   +2 **c or *u***

\# of defects per walk - if walks are the same length, then c; if walks of diff. lengths, then u

(b) The number of 3-point shots that the RHIT basketball team attempts per game.

\# of "defects" per game; games are the same length of time

Variable Chart   *p* or *np*   +2 **c or *u***

(c) The number of parts of this problem that a student correctly answers out of the total (10).

C is not MOST correct since we know # of problems is n = 10

Variable Chart   +2 ***p* or *np***   c or *u*

We can make a proportion of correct out of 10

(d) The number of weeds per square foot blocks in my backyard

Variable Chart   *p* or *np*   +2 **c or *u***

\# of defects per unit area

(e) For each week, the number of weeknights that I go to bed after 2 a.m.

C is not MOST correct since we know the # of nights is n = 7

Variable Chart   +2 ***p* or *np***   c or *u*

We can make a proportion since every week has 7 days

(f) At the Texas Roadhouse restaurant, the time between arriving and being seated.

measurement data   +2 **Variable Chart**   *p* or *np*   c or *u*

(g) Texas Roadhouse restaurant sets specification limits for the time customers have to wait to be seated in which the LSL is 1 minute, and the USL is 8 minutes. The daily number of customers who are seated within these specification limits.

hmm... I'm assuming they don't know total # of customers per day

Variable Chart   *p* or *np*   +2.5 **c or *u***

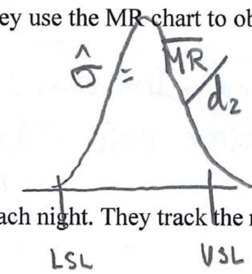
\# of customers per unit time between 1 and 8 minutes

Difficult!

(h) Texas Roadhouse restaurant sets specification limits for the time customers have to wait to be seated in which the LSL is 1 minute, and the USL is 8 minutes.

- Each night they create a control chart of individual customer wait times, and they use the MR chart to obtain an estimate for $\hat{\sigma}$.
- With this $\hat{\sigma}$ and the specification limits, they determine a value for Cp.
- The restaurant tracks these daily Cp values on a control chart.

$\hat{\sigma} = \overline{MR}/d_2$ = value



+2.5 **Variable Chart**   *p* or *np*   c or *u*

$C_p = \frac{VOC}{VOP}$ = value

each day they get a diff. C_p value: $C_{p_1}, C_{p_2}, C_{p_3}, C_{p_4}, \ldots$ measurement data

(i) At Texas Roadhouse restaurant, they know the number of tables that they serve each night. They track the number or proportion of those tables that only order water as beverages.

they can make a prop out of # tables w/ water and total # of tables

Variable Chart   +2.5 ***p* or *np***   c or *u*

(j) The number of RHIT faculty, staff, and students who eat at Texas Roadhouse each week

Variable Chart   *p* or *np*   **c or *u*** +2.5

\# per week

I'm assuming the total # of faculty, staff, & students not known

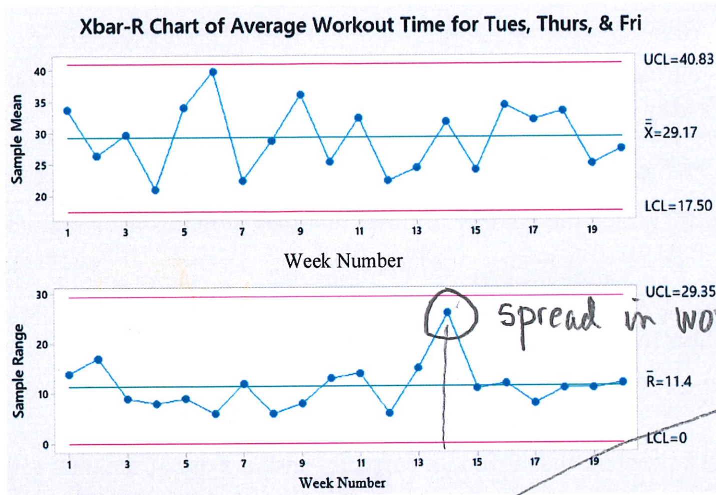
+22

2

2. I exercise with a trainer three mornings a week on Tuesday, Thursday, and Friday. For the most recent 20 weeks, I've averaged my workouts times per week (in minutes) and tracked them on an Xbar-R chart.

We can find Cp for part (c):

$$C_p = \frac{USL - LSL}{6\hat{\sigma}} = \frac{43-17}{6C} \approx$$



spread in workouts for Tues, Thurs, Fri in Week 14

This STATEMENT is NOT true - can't compare control spread and spec. spread to know if Cp is > 1, < 1, or 1

NOT $d_2 = 3.735$ for $k = 20$ gives $\hat{\sigma} \approx 3.05$

I set from specification limits as LSL = 17 minutes to USL = 43. Answer the following correct to ***2 decimal places.***

(a) [+3] Determine the values of $\hat{\mu}$ and $\hat{\sigma}$.

$\hat{\mu} \cong$ 29.17 minutes +1

$\hat{\sigma} = \dfrac{\overline{MR}}{d_2} \cong \dfrac{11.4}{1.693} \cong 6.73$ +2

for $n = 3$

(b) [+3] The largest spread in my daily workout times happened during which week number? 14 +3

looking for week w/ largest R value

(c) [+3] True or False. Since USL – LSL is greater than UCL – LCL, then Cp > 1. True False +3

can't compare these 2 in this way since control limits are an AVERAGE of 3 values; the spec limits are for single values

(d) [+5] Determine the value of Cpk.

Grade wrt part (a) $\hat{\sigma}$.

$$C_{pk} = C_{pl} = \frac{\hat{\mu} - LSL}{3\hat{\sigma}} \cong 0.60 \quad +5$$

29.17, 17, 6.73

WRONG $C_{pk} \approx 1.33$ for 20

(e) [+3] For every ~~set of 20 weeks,~~ week I decide to track the number of days in that week that I exercised more than 30 minutes. What chart would I use to track ~~the number of days that I worked out more than 30 minutes over this 20-day period?~~ this data? exercised ~~in a week.~~ week

Variable Chart p or np +3 c or u

fix wording - I'm using 2 different time units - days vs weeks

I'll accept either p/np or c/u

I'm making a proportion of the # of days over 30 minutes and the

(f) [+2] Provide a value for $\hat{\mu}$ that would cause the Cpk value to be negative, if possible, for this example. If it's not possible, just state, "not possible."

+2 > 43.0

any value for $\hat{\mu}$ that is greater than the USL OR less than the LSL

< 17.0

(g) [+2] Provide a value for $\hat{\mu}$ that would cause my Cp value to be negative, if possible, for this example. If it's not possible, just state, "not possible."

+2 Cp is NEVER negative!

not possible

Both the VOC = USL - LSL > 0, and VOP = $6\hat{\sigma}$, where $\hat{\sigma} > 0$, are positive

$$C_p = \frac{VOC > 0}{VOP > 0} = > 0.$$

+43

Since Cpk and Cp are so different, we know the process mean is NOT centered between the LSL, USL

$\hat{\mu} = 5.43$ oz $\hat{\sigma} = 0.012$ oz

no Type II error!

3

Students confuse control limits w/ specification limits

3. [+3 each] A process for filling yogurt containers is normally distributed and in-control. The process average is 5.43 ounces and the "within" process standard deviation is 0.012 oz. The specification limits set in the factory are 5.25 to 5.4 oz. The capability calculations are Cp = 2.083 and Cpk = -0.833.

LSL USL

being negative - it's very relevant

Answer **True or False** regarding the following statements regarding this process.

(a) Since the process is close to 6σ accuracy, the Cpk value is irrelevant. True False +3

Cp * 3 ≈ Sigma Level

(b) This process must be experiencing Type II Error. True False +3

We are told that it's in-control, the capability values say nothing about Type II error

(c) The process mean must not be centered on the control chart. True +3 False

We know it's not centered between the spec limits because of Cp and Cpk values

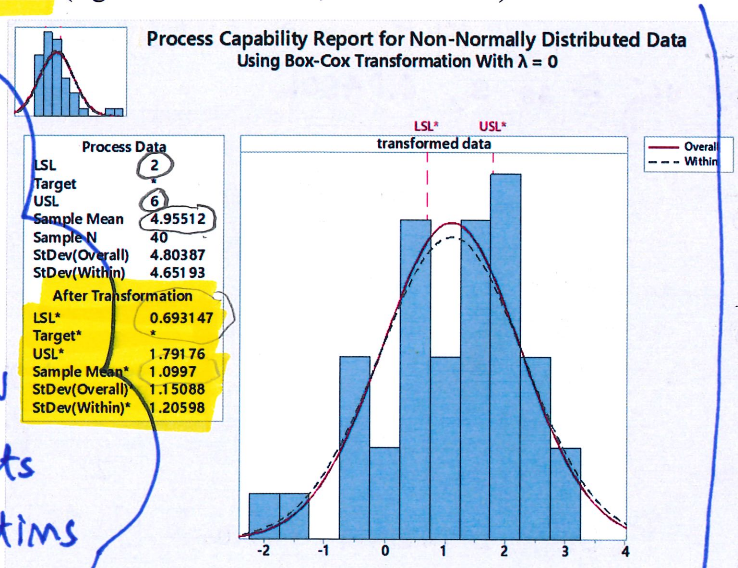
(d) The "bell" of the process's normal distribution is below the lower specification limit. True False +3

it probably IS centered since the process is in-control

Although Cpk is negative, $\hat{\mu}$ is ABOVE the UCL

4. We have a process with non-normally distributed data that was transformed to normal in the Process Capability Report below. Compute the following values. The answers have all been rounded correctly to 2 decimal places using the entire values given below (e.g. LSL* = 0.693147, instead of 0.69).

Cp and Cpk don't tell us anything about a process being in or out-of-control - they only tell us how well a process meets customer specifications



Since the data has been transformed, we use the transformed values to determine the capability indices

(a) [+3] Determine the value of Cp.

A. 0.04	B. 0.07	C. 0.08	D. 0.10	E. 0.11	F. 0.12	G. 0.14
H. 0.15 +3	I. 0.16	J. 0.19	K. 0.20	L. 0.28	M. 0.29	N. 0.30
O. 0.76	P. 0.83	Q. 0.86	R. 0.91	S. 0.95	T. 1.00	U. 1.10

$$Cp = \frac{1.79176 - 0.693147}{6 \cdot \hat{\sigma}_{within}} \cong 0.15$$

1.20...

(b) [+3] Determine the value of Ppk.

A. 0.04	B. 0.07	C. 0.08	D. 0.10	E. 0.11	F. 0.12	G. 0.14
H. 0.15	I. 0.16	J. 0.19	K. 0.20	L. 0.28	M. 0.29	N. 0.30
O. 0.76	P. 0.83	Q. 0.86	R. 0.91	S. 0.95	T. 1.00	U. 1.10

if someone has 0.1178 and chooses 0.11 - give full credit!

FUTURE: Say circle ALL that are TRUE

5. [+3] Which **one** of the following statements is true regarding Control Limits and Specification Limits?

A. There is ~~no~~ difference between the terms; both are used to indicate if a process is in control.

B. Control Limits are ~~set~~ by the customers; Specification Limits ~~are derived~~ by the process.

+3 C. Control Limits are derived by the process; Specification Limits are set by the customer.

one of these have to be true - opposite statement

D. Control Limits are typically 3 standard deviations from the mean; Specification Limits are typically 3 standard deviations from the target.

+64

$$P_{pk} = P_{pl} = \frac{\overset{USL^*}{1.0997} - \overset{LSL^*}{0.693147}}{3 \cdot \hat{\sigma}_{overall}} \cong 0.1178$$

1.15...

this is F, though some ppl still circled E

② Assume normality; Type I error: ≈ 0.00135 Partial credit

① Assume mortgage errors are normal w/ mean = 11.33, std dev = $\sqrt{11.33} \approx 3.37$

0.00135

(-2) four

④

6. The operations manager of a bank's mortgage services department is concerned about the number of errors entered into mortgage applications. Each week, a random application is drawn, and the number of incorrect entries is recorded (e.g. 15, 12, 19, …, 15, 3). The average errors over this period is 11.33. The data is in the Minitab worksheet for this exam. Provide answers correct to ~~two~~ decimal places.

(a) [+3] Determine the UCL for the most ***appropriate*** control chart for tracking this situation. Show your work or state how you determined this value in Minitab.

C Chart: $UCL = 11.33 + 3 \cdot \sqrt{11.33} \approx 21.43$ or C chart in Minitab.

(b) [+4] If the process ***is*** in-control, what's the most exact probability of obtaining a point beyond the UCL? You can provide an approximation for partial credit. Show your work or explain your reasoning.

21.43

$\hat{\sigma} \approx 3.367$

11.33

1.23

C Chart → Mortgage Errors has a Poisson distribution w/ mean 11.33

point greater than or equal to 22

$P(\text{Point} > 21.43) = \sum_{x=22}^{\infty} \frac{e^{-11.33} \cdot 11.33^x}{x!}$

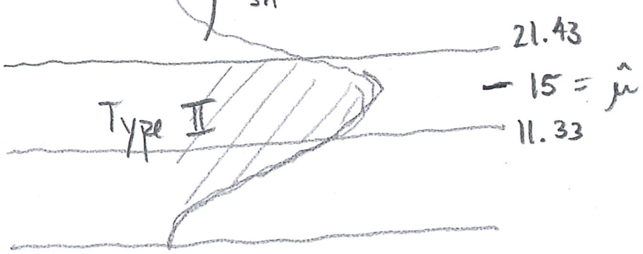
(-3) Normal approx using $\hat{\sigma}$ as s, 0.04506

or Minitab > Prob Dist Plot > Poisson w/ Mean = 11.33 Right tail; X = 22 ≈ 0.0032

0.006145 (-1) start sum @ X = 21.43 − Minitab sums X = 21 to ∞

(c) [+5] Assume that the average number of errors shifts. What's the most exact probability of committing a Type II Error given the mean has shifted to 15? Show your work. You can earn partial credit by providing an approximation.

New mean: $\hat{\mu}_{sh} = 15$



$P(\text{Type II error}) = P(\text{point between } \lceil 1.23 \rceil \text{ and } \lfloor 21.43 \rfloor) = \sum_{x=2}^{21} \frac{e^{-15} \cdot 15^x}{x!} \approx 0.947$

Normal approx w/ $\hat{\sigma}$ as s, ~~0.04506~~ 0.8597

7. [+4] Assume that the mean number of surface flaws per square meter is 2.8. An inspection operation checks the number of surface flaws per square meter and plots it on the appropriate control chart. What is the upper control limit of the appropriate control chart? Assume the upper control limit is set as a typical 3-sigma control limit.

A. 4.47 B. 5.60 C. 5.70 D. 7.82 E. 11.2

E. We don't have enough information to compute the UCL for the correct control chart.

$UCL = 2.8 + 3 \cdot \sqrt{2.8} = 7.82$

8. [+5] For a given process and its specification limits, you have computed Ppk = 0.79 and Cpk = 0.8. Which of the following statements is true about your process? Select **all** the correct choices.

A. The computations of Ppk and Cpk are incorrect because it should always be the case that Ppk is greater than Cpk.

B. The process is not in control. One mistake: −1.5; Two mistakes: −3, 3+: −5

C. The "overall" process standard deviation and the "within" process standard deviation are very close in value.

D. This process must be experiencing Type I Error.

E. The values of Pp and Cp would be smaller in value to Ppk and Cpk, respectively.

F. The process mean must not be centered on the control chart.

G. The mean of the process is not centered between the specification limits.

$X_2 \sim Normal(\hat{\mu} = 15, \hat{\sigma} \approx 3.67)$

+85

* if use normal curve: $P(1.23 < X_1 < 21.43) \approx 0.9514$

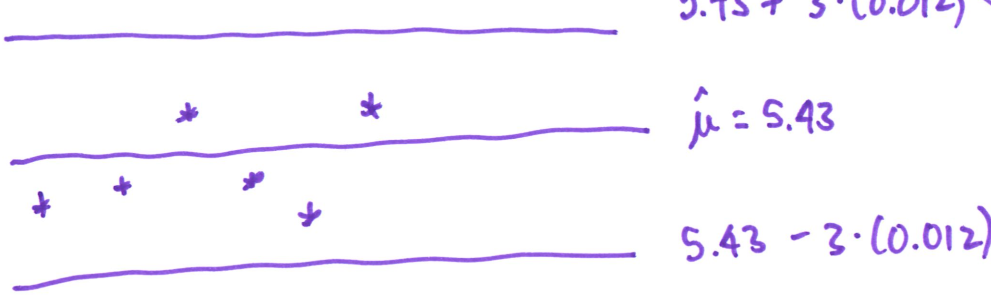
$X_1 \sim Normal(\hat{\mu} = 15, \hat{\sigma} = \sqrt{15})$ 3.873 $P(1.23 < X_2 < 21.43) \approx 0.9719$

Exam 3.

#3. $\hat{\mu} = 5.43, \quad \hat{\sigma} = 0.012$

Confusing Control Limits and Spec Limits

I-MR

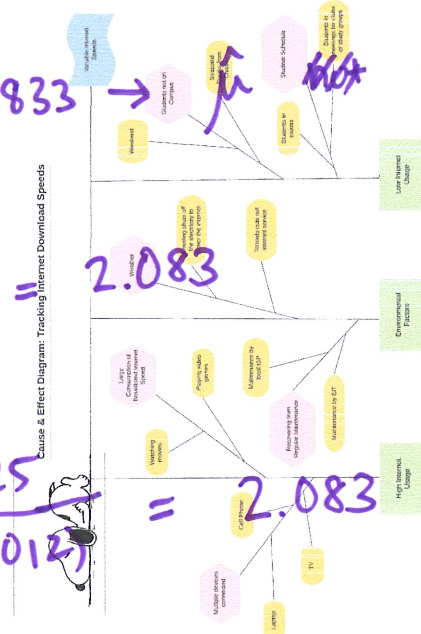


5.25 5.4

LSL = ~~?~~ USL = ~~?~~

$C_p = 2.083, \quad C_{pk} = -0.833$

We know $C_{pk} = -0.833 \rightarrow \hat{\mu}$ ~~not~~ outside of 5.25, 5.4



$$C_p = \frac{USL - LSL}{6 \cdot \hat{\sigma}} = 2.083$$

$$\frac{5.4 - 5.25}{6 \cdot (0.012)} = 2.083$$

$$C_{pk} = \frac{5.43 - 5.4}{3 \cdot (0.012)} = -0.833$$

5

9. With the mailroom opening at 11:30 a.m., I have noticed the wait times for being served can be long. The times are non-normal. In the Minitab worksheet for this exam, I have a column of $n = 35$ wait times.

(a) [+3] Use Minitab to determine one distribution that "fits" the mail time data, where "fits" means the distribution's p-value is at least 0.05. Make sure the distribution is NOT a transformation (e.g. Box-Cox or Johnson transformation). Write down the name of the distribution. [There is more than one correct answer.]

Exponential : p ≈ 0.197

Weibull p > 0.25

Gamma : p-val > 0.25

(b) [+5] Use the distribution that you identified in part (a) to determine its capability indices Pp and Ppk given the specification limits of LSL = 1 and USL = 4. Just sketch the graph and report the index values.

Exponential : mean : 4.59527

Pp = 0.18, Ppk = 0.07

Weibull : Pp = 0.2, Ppk = 0.04

Gamma : Pp = 0.2, Ppk = 0.05