MIT 2.008 Design and Manufacturing II

Spring 2023

March 22, 2023

- Closed Book
- All work for CREDIT must be completed in this quiz document
- You are allowed one double-sided, handwritten 8.5” x 11” notes sheet
- Calculators are allowed
- Box your solutions!

Name: **SOLUTIONS**

Problem 1		Out of 15 points
Problem 2		Out of 20 points
Problem 3		Out of 25 points
Problem 4		Out of 20 points
Problem 5		Out of 20 points
Total		**100 points**

Problem 1

Circle or write in the correct answer(s). **1 pt each choice (no partial credit), 15 pts total**

a) Injection molding, when starting from pellets, begins with a (**filling / plasticizing**) step where the pellets are fed into a screw-type extruder via a hopper.

b) In injection molding, deformation due to warpage can be reduced by reducing the cooling time and lowering the ejection speed. **True / False**

c) Injection-molded uniform part thickness helps the plastic cool evenly and avoid residual stresses. **True / False**

d) Improving the surface finish on an injection mold can help decrease flash defects. **True / False**

e) In thermoforming, it is a general rule of thumb that the area of the plastic sheet that touches the mold (**first / last**) will be the thinnest.

f) Increasing the draw ratio in thermoforming is likely to reduce tearing defects. **True / False**

g) (**Heating / Cooling**) is usually the rate-limiting step in thermoforming since it is limited by the rate of convective and radiative heat transfer.

h) You are turning a part on a lathe with a constant surface speed, feed, and depth of cut. If you step down to a new diameter that is half of the original diameter, the cutting force (**halves / approximately stays the same / doubles**).

i) In machining, it's possible to have zero thrust force. **True / False**

j) The angle between the plane of a cut and the surface of a workpiece in machining is known as the (**rake angle / shear angle**).

k) In machining, you want to avoid changing feed and surface speed in tandem with each other to make sure you are optimizing your process. **True / False**

l) The insertion force for press fit is linear with insertion depth. **True / False**

m) With regards to process control, it is possible to be in control but fail to meet specification requirements. **True / False**

n) When Cp > Cpk, it indicates that the average is centered on the target value. **True / False**

o) Your tolerances always have to be +/- 3 standard deviations. **True / False**

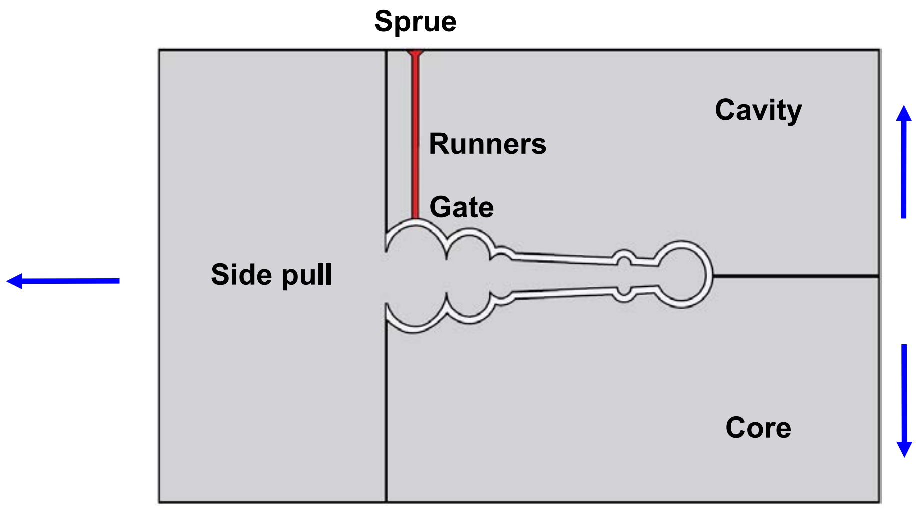
Problem 2 - Injection Molding 20 pts total

Let's analyze the following parts:

Figure 1. *Pawn chess piece.*

Figure 2. *Bottle cap.*

a) Sketch cross sections of the molds used to make **both** these parts, **identifying and labeling** all critical features of the part and components of the mold. **(10 pts)**



You could also use a vertical orientation for this sketch.

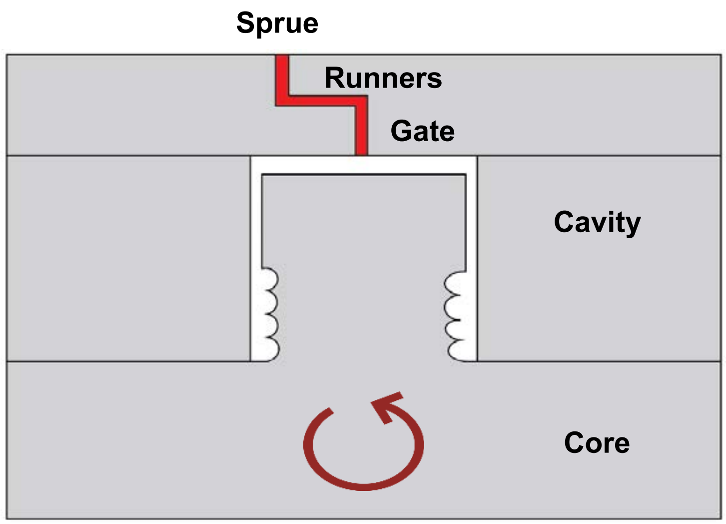
1 pt for core/cavity

1 pt for runner/sprue

1 pt for gate

1 pt for side pull

1 pt for part geometry as negative space



1 pt for core/cavity

1 pt for runner/sprue

1 pt for gate

1 pt for rotation

1 pt for part geometry as negative space

You are hired as a consultant by a company that manufactures jewel CD cases. In particular, they are having trouble with the black piece that holds the CD (**Figure 3**). The processing conditions and material properties are listed in the table below.

Injection temperature (T)	260 °C
Injection pressure (P_i)	3000 psi
Hold pressure (P_h)	5000 psi
Cooling time (t_c)	10 s
Material	Polystyrene
Thermal diffusivity (α)	5.9 x 10^{-4} cm^2/s
Coefficient of thermal expansion (a)	8 x 10^{-5} 1/K

Figure 3. *CD case.*

b) If the company is making **four** of these parts per mold, how much clamp force needs to be applied by the injection molding machine? **(4 pts)**

$F_{clamp} = \Delta PA = 5000\ psi * 4.5\ in * 5.5\ in * 4\ cavities = \mathbf{495000\ lbs} = \mathbf{247.5\ tons}$

2 pts for equation

1 pt for cavities

1 pt for answer

c) The company is having problems with case breaking in the locations shown in **Figure 4**. Why are the cases breaking here? It may be helpful to use a sketch to show your reasoning. **(3 pts)**

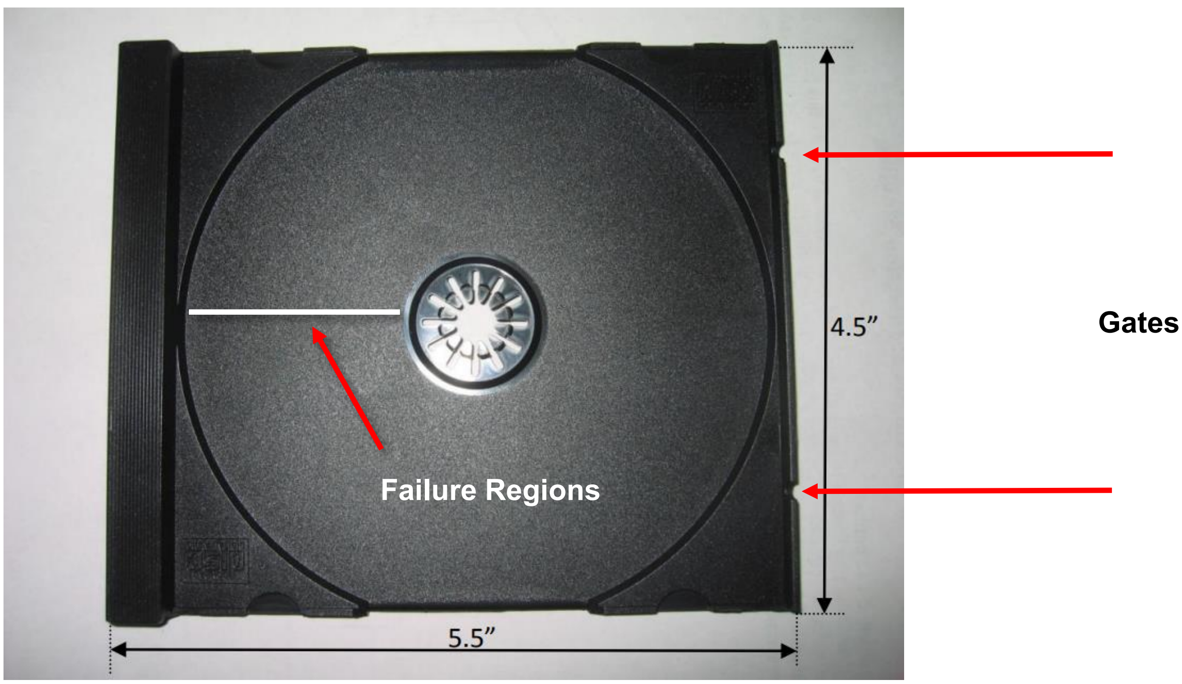


Figure 4. *CD case failure regions.*

The melt is injected from two ports on the edge of the case. The regions shown here are the weld lines in the part where the material is weakest.

2 pts for explanation / sketch

1 pt for stating that they are weld lines

d) What changes would you recommend to alleviate this issue? **(3 pts)**

The problem could be fixed by increasing the melt temperature and/or the injection pressure. If you happen to know that the melting point of polystyrene is 240 °C, then you'd probably start by increasing the temperature since they are operating so close to the melting point.

2 pts for recommendations

1 pt for temperature increase

Problem 3 - Cutting **25 pts total**

The iPhone 6 housing (shown below) is to be machined from an aluminum (6000 series) block.

Figure 5. *iPhone 6 aluminum housing.*

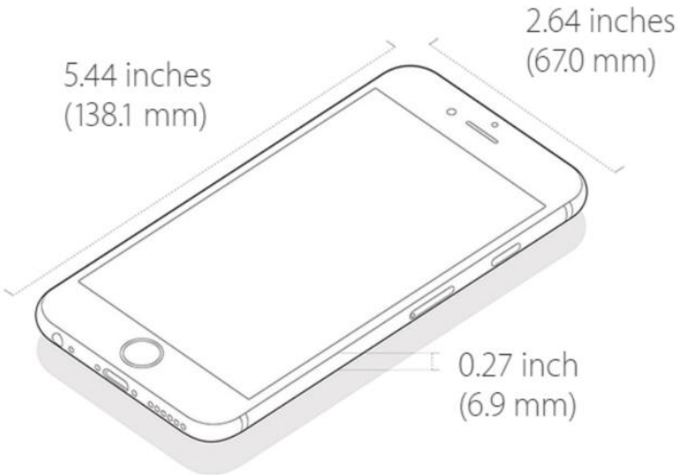


Figure 6. *iPhone 6 dimensions.*

a) If **half** of the workpiece volume is removed by machining using one 0.25-in-diameter, 4-flute (teeth) end-mill, estimate the machining time. Refer to the table below for machining parameters. **(10 pts)**

	Specific energy (hp-min/in^3)	**Feed** (in/tooth)	**Cutting speed** (center of tool relative to workpiece) (ft/min)	**Depth of cut** (in)
Aluminum	0.30	0.002	150	0.05

Cutting speed is the speed of the cutting edge of the mill. Therefore,

$$\pi DN = v_c \rightarrow N = \frac{v_c}{\pi D} = \frac{150\ ft/min}{\pi \times \frac{0.25}{12} ft} = 2291.83\ rpm$$

Feed rate is essentially the length of material removed per unit time.

$$v = N \times n \times f = 2291.83\ rpm\ \times 4\ \frac{teeth}{rev} \times 0.002 \frac{in}{tooth}\ = 18.33\ in/min$$

Material removal rate is related to the feed rate and the cross-sectional area of the cut.

$$MRR = wdv = 0.25\ in \times 0.05\ in \times 18.33 \frac{in}{min} = 0.23\ in^3/min$$

It is also the volume of material removed per unit time.

$$MRR = \frac{V}{t} \rightarrow t = \frac{V}{MRR} = \frac{0.5 \times 0.27 \times 5.44 \times 2.64}{0.23} = \mathbf{8.46\ min}$$

1 pt for N equation

1 pt for N answer

1 pt for v equation

1 pt for v answer

1 pt for MRR equation

1 pt for MRR answer

2 pts for t equation

2 pts for t answer

b) Calculate the power requirement for this operation. Compare this value to the power requirement of the HAAS VF-2ss, which is ~20 hp. Are we limited by power? If not, what could we be limited by? **(5 pts)**

To calculate power:

$$P = u_s MRR = 0.30 \frac{hp - min}{in^3} \times 0.23 \frac{in^3}{min} = \mathbf{0.069\ hp}$$

We are NOT limited by power. We could be limited by tool breakage at some point.

1 pt for P equation

1 pt for P answer

1 pt for answer

2 pts for justification

c) To optimize surface finish, the manufacturers decide to change end mills for the final 20% of the machining process. Revise your estimate assuming that 80% of the machining is done using the tool in part (a) and the remaining 20% is done using a 1/16-in-diameter, 2-flute tool with the same machining parameters. **(10 pts)**

80% of the machining work corresponds to 40% of the workpiece volume,

$$t_1 = \frac{V_1}{MRR} = \frac{0.4 \times 0.27 \times 5.44 \times 2.64}{0.23} = 6.77\ min$$

The remaining 20% corresponds to 10% of the workpiece volume. Since the tool is different, the new MRR and time and calculated:

$$N_2 = \frac{150\ ft/min}{\pi \times \frac{1/16}{12} ft} = 9167.32\ rpm$$

$$v_2 = 9167.32\ rpm\ \times 2 \frac{teeth}{rev} \times 0.002 \frac{in}{tooth} = 36.67\ in/min$$

$$MRR_2 = \frac{1}{16} in \times 0.05\ in \times 36.67 \frac{in}{min} = 0.11\ in^3/min$$

$$t_2 = \frac{V_2}{MRR_2} = \frac{0.1 \times 0.27 \times 5.44 \times 2.64}{0.11} = 3.38\ min$$

The total machining time is given by:

$$t = t_1 + t_2 = 6.77 + 3.38 = \mathbf{10.15\ min}$$

1 pt for t_1 equation

1 pt for t_1 answer

1 pt for N_2 equation

1 pt for N_2 answer

1 pt for v_2 equation

1 pt for v_2 answer

1 pt for MRR_2 equation

1 pt for MRR_2 answer

1 pt for t_2 answer

1 pt for t answer

Problem 4 – Assembly & Joining **20 pts total**

Shrink fits (analogous to press fits) take advantage of thermal expansion to hold two components together without additional fixturing or adhesives. Consider a 5 mm thick aluminum ring of inner radius (r_i) 4 cm that was shrunk to fit into an aluminum outer ring with outer radius (r_o) 10 cm. The interface (R) between them is thus 4.5 cm from the center. Their depths (into the page) are equal to 1.5 cm. The static friction coefficient between them is 0.7. Use E = 70 GPa and α = 20 * 10^{-6} 1/K.

The process of assembling them together was:

- Heat the outer ring to 200 ˚C above the ambient until the inner radius of the outer ring could smoothly fit over the inner ring.
- Allow assembly to cool to ambient.

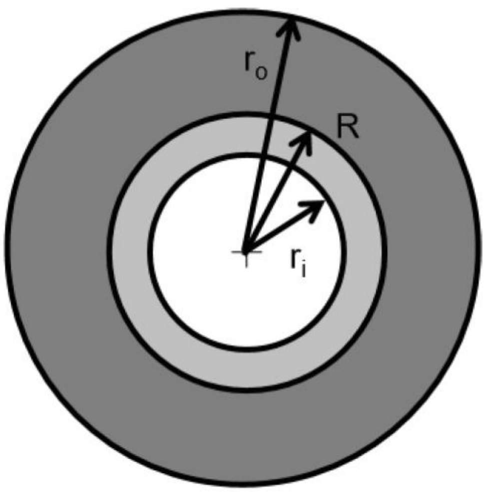


Figure 7. *Joining of two aluminum rings.*

a) What is the force required to separate the two rings after they have reached thermal equilibrium with the ambient? **(5 pts)**

This is a classic example of shrink fitting, for which we can apply the "Press Fit" equation:

$$P = \frac{E}{R} * \delta * [\frac{(r_o{}^2 - R^2)*(R^2 - r_i{}^2)}{2*R^2*(r_o{}^2 - r_i{}^2)}]$$

Inserting the corresponding values from our situation r_o = 0.1 m, r_i = 0.04 m, R = 0.045 m, E = 70 GPa and α = 20 * 10^{-6} 1/K , we get:

$$P = \frac{70*10^9\ Pa}{0.045\ m} * \left(20 * 10^{-6}\frac{1}{K} * 0.045m * 200K\right) * [\frac{(0.1^2-0.045^2)*(0.045^2-0.04^2)}{2*0.045^2*(0.1^2-0.04^2)}$$

$$P_{interface} = 1.56 * 10^{12}\frac{Pa}{m} * (0.00018m) * (0.0996) = 2.80 * 10^7\ Pa$$

Then,

$$F_{remove} = \mu_{static} * P * 2 * \pi * R * x_{remove} = 0.7 * (2.80 * 10^7 Pa) * 2 * \pi * (0.045m) * (0.015m)$$

$$F_{remove} = \mathbf{83.1\ kN}$$

This is the force required to lift almost five 2-ton cars!

1 pt for delta expression substitution

1 pt for correct radius used

1 pt for pressure calculation

1pt for force equation

1 pt for answer/units

b) If the coefficient of kinetic friction is 0.55, what is the work required to complete the separation? (Press fit equations can apply here). **(5 pts)**

Note that the coefficient of friction used to determine the separation force is the static friction coefficient. We will need to transition to using the coefficient of kinetic friction in the case of separation because we assume continuous sliding. The work required to separate these rings is:

$$Work_{remove} = \int_0^{x_{remove}} F_{remove} \cdot dx = \int_0^{x_{remove}} \mu_{kinetic} \cdot P \cdot 2 \cdot \pi \cdot R \cdot x \cdot dx$$

$$Work = \int_0^{x_{insert}} F_{insert} \cdot dx = \int_0^{x_{remove}} \mu_{kinetic} \cdot P \cdot 2 \cdot \pi \cdot R \cdot x \cdot dx = \mu_{kinetic} \cdot P \cdot \pi \cdot R \cdot x_{remove}^2$$

$$Work = 0.55 \cdot 2.80 \cdot 10^7 Pa \cdot \pi \cdot 0.045m \cdot (0.015m)^2 = \mathbf{490\ J}$$

1 pt for work integral setup

1 pt for work integral simplification

1 pt for calculation

1 pt for correct friction coefficient

1 pt answer/units

c) If the thickness of the inner ring is doubled and the interface radius unchanged, **calculate** what happens to the force you calculated in part a) and the work needed to separate the assembly you calculated in part b)? **(5 pts)**

If we double the inner ring thickness (and keep the interface radius R the same), the new inner radius of the joined part is $r_i = 0.035m$

$$P_{2xinner} = \frac{70*10^9\ Pa}{0.045\ m} * \left(20 * 10^{-6}\frac{1}{K} * 0.045m * 200K\right) * [\frac{(0.1^2-0.045^2)*(0.045^2-0.035^2)}{2*0.045^2*(0.1^2-0.035^2)}]$$

$$P_{2xinner} = 5.03 * 10^7 Pa$$

Then,

$$F_{remove} = \mu_{static} * P * 2 * \pi * R * x_{remove} = 0.7 * 5.03 * 10^7 Pa * 2 * \pi * (0.045m) * (0.015m)$$

$$F_{remove} = \mathbf{149.3\ kN}$$

$$Work_{remove,double\ inner\ diameter} = \mathbf{880\ J}$$

1 pt for inner ring pressure

1 pt for inner ring force

1 pt for inner ring work

2 pt answer (ok if correct answer but qualitative with reasoning)

d) What about when the outer ring doubles its thickness, keeping the original inner ring thickness and interface radius the same? Please **calculate** and **explain** what happens to the force you calculated in part a) and the work needed to separate the assembly you calculated in part b)? **(5 pts)**

If we double the outer ring thickness (and keep the interface radius R the same and go back to the original r_i), the new outer radius of the joined part is $r_o = 0.155m$

$$P_{2xouter} = \frac{70*10^9\ Pa}{0.045\ m} * \left(20 * 10^{-6}\frac{1}{K} * 0.045m * 200K\right) * [\frac{(0.155^2-0.045^2)*(0.045^2-0.04^2)}{2*0.045^2*(0.155^2-0.04^2)}]$$

$$P_{2xouter} = 2.88 * 10^7 Pa$$

Then,

$$F_{remove} = \mu_{static} * P * 2 * \pi * R * x_{remove} = 0.7 * 2.88 * 10^7 Pa * 2 * \pi * (0.045m) * (0.015m)$$

$$F_{remove} = \mathbf{85.5\ kN}$$

$$Work_{remove,double\ outer\ diameter} = \mathbf{504\ J}$$

There is virtually no (<3%) change in force or work required to separate the two parts when we double the outer ring thickness! What is indicated then is that the thinner inner ring is more prone to deformation due to compression of the thicker outer ring, so increasing its thickness has a much greater impact on resisting radial strain (deformation) than further bolstering the already relatively thick outer ring

.

1 pt for inner ring pressure

1 pt for outer ring force

1 pt for outer ring work

2 pt justification (ok if correct answer but qualitative with reasoning)

Problem 5 - Variation / Quality Control **20 pts total**

We are tasked with improving a steel plate process to produce defect-free parts as quickly as possible. The target plate thickness is 100 cm with a USL of 103 cm and a LSL of 97 cm. Previous testing has shown that the process has a $C_p = 0.80$ and $C_{pk} = 0.20$.

a) Calculate the current mean (μ) and standard deviation (σ)? What is the percentage of NON-conforming parts? **Appendix I** provides z-score tables. **(5 pts)**

Let's start by recalling and re-writing the equations for C_p and C_{pk}:

$$\sigma = \frac{USL-LSL}{6C_p} = \frac{103\ cm-97\ cm}{6(0.80)} = \mathbf{1.25\ cm}$$

$$C_{pk} = \frac{\mu-LSL}{3\sigma}$$

$$\mu = 3\sigma C_{pk} + LSL = 3(1.25\ cm)(0.20) + 97\ cm = \mathbf{97.75\ cm}$$

This problem technically has a dual solution due to the two distinct minimum functions (USL and LSL) so 102.25 cm is also acceptable and the % of conforming parts will be the same as well.

To find the % of non-conforming parts:

$$P(non-conforming) = P(x < LSL) + P(x > USL)$$

$$P(x < LSL) = P\left(z < \frac{LSL-\mu}{\sigma}\right) = P(-0.6) \approx 0.27425$$

$$P(x > USL) = P\left(z > \frac{USL-\mu}{\sigma}\right) = P(4.2) \approx 0.00001$$

$$P(non-conforming) = 0.27425 + 0.00001 = \mathbf{0.27426}$$

1 pt for sigma equation

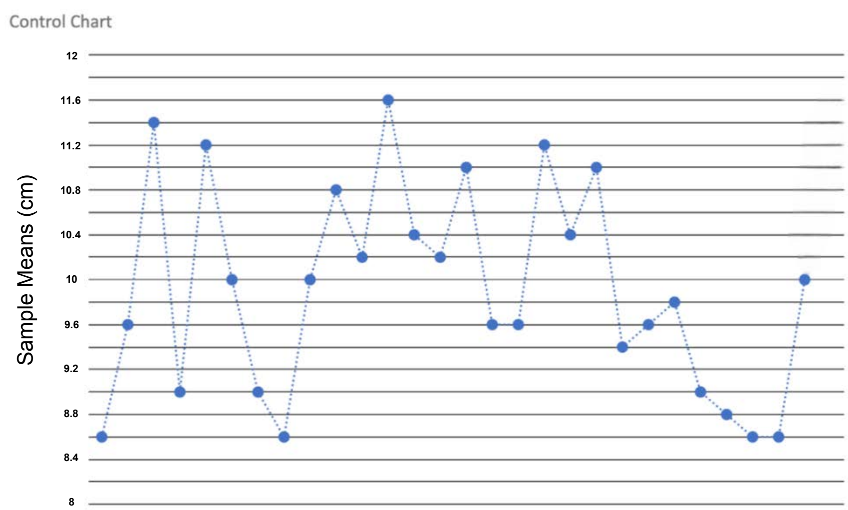
1 pt for sigma answer

1 pt for mean equation

1 pt for mean answer

1 pt for % non-conforming parts equation

Now, let's focus on quality control for the mean sample shown below. A distribution of 30 **sample means** is monitored to ensure whether the process is in control. Each sample mean is comprised of 16 **samples**. The grand mean, which is the average of the sample means, is 10 cm. The standard deviation of the parts is 1.6 cm.



b) Calculate the UCL ($3\bar{\sigma}$) and LCL ($-3\bar{\sigma}$). **(4 pts)**

Using the following relations:

$$\sigma = \frac{\bar{\sigma}}{\sqrt{n}}$$

$$UCL \text{ and } LCL = \bar{\bar{\mu}} \pm 3\sigma$$

Where $\bar{\bar{\mu}}$ is the grand mean and σ is the standard deviation.

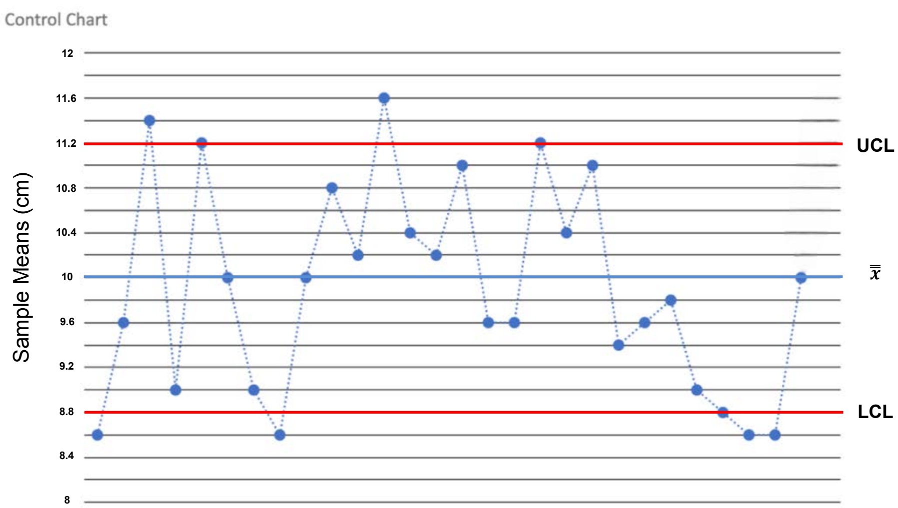
$UCL \ = 10 + 3(0.25)(1.6) = \mathbf{11.2}$

$LCL \ = 10 - 3(0.25)(1.6) = \mathbf{8.8}$

2 pts for UCL answer

2 pts for LCL answer

c) Plot on the graph above the following components: UCL, LCL, and $\bar{\bar{\mu}}$. **(6 pts)**



2 pts for UCL

2 pts for LCL

2 pts for $\bar{\bar{\mu}}$

d) Is the process in control? Please explain in detail, draw any other items on the graph needed and quote specific references if used. (**5 pts)**

Applying the Western Electric Rules:

1. Points outside limits.
2. 2-3 consecutive points outside 2 sigmas.
3. Four of five consecutive points outside 1 sigma.
4. Run of 8 consecutive points on one side of center.

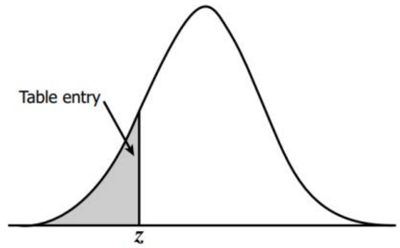
You only had to say one rule was out of control to get full credit, you did not need to go through each in detail if you saw it right away. Furthermore, you could also say that the process was out of control at different points in time but was later corrected.

2 pts for answer

3 pts for justification

Appendix I: Z-score Table

$$z = \frac{x - \mu}{\sigma}$$



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
–3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
–3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
–3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
–3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
–3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
–2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
–2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
–2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
–2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
–2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
–2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
–2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
–2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
–2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
–2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
–1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
–1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
–1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
–1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
–1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
–1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
–1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
–1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
–1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
–1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
–0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
–0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
–0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
–0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
–0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
–0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
–0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
–0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
–0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
–0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998