MIT 2.008 Design and Manufacturing II
Spring 2021
March 31, 2021

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

TA SOLUTIONS

Problem 1		Out of 16 points
Problem 2		Out of 20 points
Problem 3		Out of 16 points
Problem 4		Out of 24 points
Problem 5		Out of 24 points
Total		**100 points**

Problem 1

Circle or write in the correct answer(s). **1 pt each choice (no partial credit), 16 pts total**

Injection Molding

Your injection molding machine has a fixed maximum injection pressure. If you are producing two parts of equivalent volume, a _______ (small, thick part / large, thin part) has the greatest risk of a short-shot defect.

Venting air can be a reason for choosing a parting line location. True / False

Using a ______ (higher/lower) viscosity material would reduce the clamp force.

The packing pressure is usually ______ (higher/lower) than the injection pressure.

Thermoforming

Draft angles are needed on both thermoformed and injection molded parts. True / False

Additive Manufacturing

A larger build volume directly increases your rate of production. True / False

SLA normally has _______ (higher/lower) resolution than FDM parts.

Cutting

You mill a pocket with a given set of parameters (depth of cut, width of cut, feed rate, etc.) If you double the spindle speed (while holding all other parameters the same), the cutting force _____ (stays the same / doubles)

If you double the feed rate, the cutting force _____ (stays the same / doubles)

A major assumption to simplify the geometry for analysis is ______ (orthogonal/oblique) cutting.

You can have a negative rake angle. True / False

When the shear angle increases, the shear strain _______ (increases / decreases).

Variation / Quality Control

If you set the tolerance of a shaft/stem diameter as 0.50” +/- 0.01”, it is the ____ (UCL / USL).

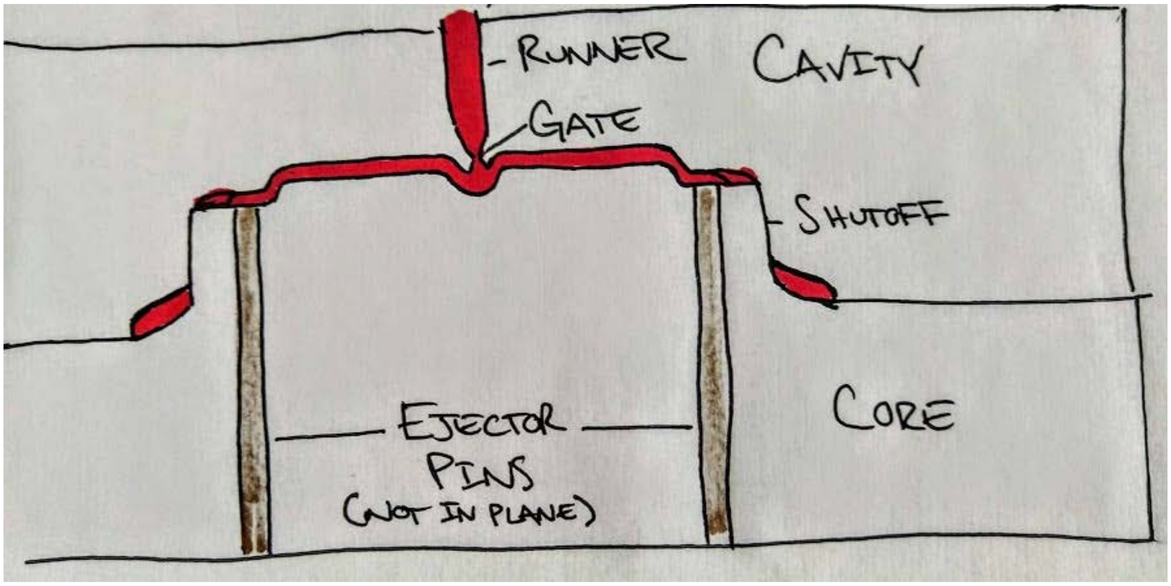
According to the central limit theorem, _____ (more/less) samples increase the precision of the estimate of the average.

As the subgroup size decreases, the UCL and LCL move _____ (closer/further) to the center line, making the control chart ____ (more/less) sensitive to shifts in the mean.

Problem 2 - Injection Molding **20 pts**

Recall the **Can Carrier** for holding aluminum cans that we saw in the lecture breakout session. A few images of the product are shown below.

a) Sketch a cross section of the mold used to make this part, identifying and labeling critical features. Additional, full size images are included in the appendix for further inspection. For simplicity, sketch the mold at section A-A shown in the figure below, and only draw for a single can portion of the part:



*Note that ejector pins are not technically in the plane of the section, so OK if not included in the sketch

8 pts total: +2 cavity, +2 core, +2 gate, + 2 shutoff (need to show how void in part at section A-A is achieved)

b) Estimate the cycle time to make the part, if the fill time is 2 seconds. Treat the part as a single flat disk with a diameter of 60 mm and thickness of 1 mm. The part is made of HDPE (high density polyethylene) polymer, with properties given below:
   - Melting point = 130 C
   - Thermal conductivity = 0.44 W/m-K
   - Density = 960 kg/m^3
   - Specific heat capacity= 1880 J/kg-K

   Explain your calculations and reasoning.

Cycle time = Mold close (1-2s) + Injection (2 s) + Pack (8-10s) + Cooling time (?) + Mold Open (1 s) + Eject time (1s)

2 pts for cycle time assumptions (-1 if don't include steps other than injection + cooling)

Calculate cooling time

Tcool = h^2 / (4α)

2pts for equation

α = thermal conductivity / (density * specific heat capacity)

α = 0.44 W/m-K / (960 kg/m^3 * 1880 J/kg-K) = 2.44 * 10^-7 m^2 / s

Tcool = (0.001 m) ^2 / (4 * 2.44 * 10^-7 m^2 / s) = 1 s

1pt calculation

1 pt Tcool answer

Cycle time = 14-17s

1 pt cycle time

7 pts total

c) Estimate the clamping force required for the whole 4 can part, if the injection pressure is 3 MPa. You can neglect the interconnecting sections and center holding tab in your calculation.

Force = projected area * injection pressure

2 pts equation

Force = 4 * (pi * (0.03 m)^2) * 3 MPa

1 pt calculation

1 pt include x4 (4 can part)

Force = 34 kN

1pt answer

5 pts total

Problem 3 - Thermoforming + Additive Manufacturing + Defects (16 pts)

Inspect the plastic can carrier images further.

a) On the largest image in Problem 2, find and label all of the part's gates. What quality consideration did the manufacturer make with regards to the gate design/location?
They recessed the gates so that they did not need to post-process the gate nub and so consumers would not be scratched. The 4 gates are in each of the can centers to allow for radial and symmetric plastic flow.
2 pts for getting **all 4** of the gates (therefore 2 total pts for any and all)
1 pt for even/balanced/radial (+1 BONUS POINT for mentioning the recessed gate - which is actually what we were going for in this question!)
No points awarded for saying 4 gates are on the connectors

b) You find out from your customers that the can carriers keep breaking at the weld line locations that we saw in class. To counteract this issue, you decide to reduce to one gate, keeping it in the same location. Comment on an issue with this design change and another defect that it might cause instead. Support this with any fundamental analysis.
Keeping all other parameters the same, this might make the design susceptible to a short shot. This is because you now have at least 2x if not 3-4x the distance for the molten plastic to reach before it cools. It will significantly lower your ratio of flow rate versus cooling rate, causing it to cool before reaching the opposite corner considering it is non-isothermal flow. Your goal is to keep the gate location balanced.
1 pt for some sort of unbalanced or no longer symmetrical flow
1 pt for "short shot"
1 pt for lengthening distance of material travel or some version of ratio of flow rate to cooling rate or freezing because traveling through small corridor (beyond simply saying unbalanced that was the previous 1pt)

c) Instead of reducing the gates, you instead try to use the same locations but make the connectors 10x as thick to avoid fracturing. Comment on an issue with this design change and another defect that it might cause instead.
Now you would have sink marks in this area since this is much larger than the thickness of the can region. In addition, it will drastically increase the cooling time by potentially 100x.
1 pt for thickness much greater than the rest of the part and affecting cooling time
1 pt for "sink marks or warping"

d) Suggest two ways to avoid these weld lines without changing the design of the part/tooling.
Increase injection speed or increase the injection temperature or raise the mold temperature. Use a material with lower melt temperature or increase the injection pressure.
Lots of options here chosen from any of the above (and does not have to be from each group or set of ideas)
1 pt for each x 2 = 2pts

No points awarded for violating the prompt and saying something with regards to gates or part design.

e) Give two reasons why the manufacturer would not have used thermoforming for this part. Be specific about the issue and location/region affected.

1. Thermoforming would be thinner or varying thicknesses throughout and therefore and have lower strength in the connector areas not achieve the same stiffness with it's amorphous as the crystalline injection molded part to be able to carry the cans freely without tearing.
2. The tolerances on the thermoformed lip most likely would not be good enough to achieve a strong hold of the cans, in addition to the corners thinning out substantially.
3. It could be difficult to make the cut-outs or the geometry of the connectors without having a really complicated multi-stage thermoforming die

2 pt for each x 2 = 4pts

For example

1 pt for connector area and 1 pt for strength

1 pt for lip and 1pt for tolerances

No points awarded for choosing detail of the text since thermoforming can achieve this based on the coffee cup lids seen in lecture and homework and review

f) What would be an issue with using FDM to make tooling for a thermoformed part? Could this be eliminated using SLA for the tooling instead?

Similar to the issue in the first part, if FDM produced the tooling there might be poor stepping features in the curved areas of the part due to layer resolution. However, even with SLA, which would fix that issue, there might be a much longer cycle time due to the poor conduction through the 3D printed plastic versus a metallic mold that has a higher heat conductivity.

1 pt for FDM resolution or temperature

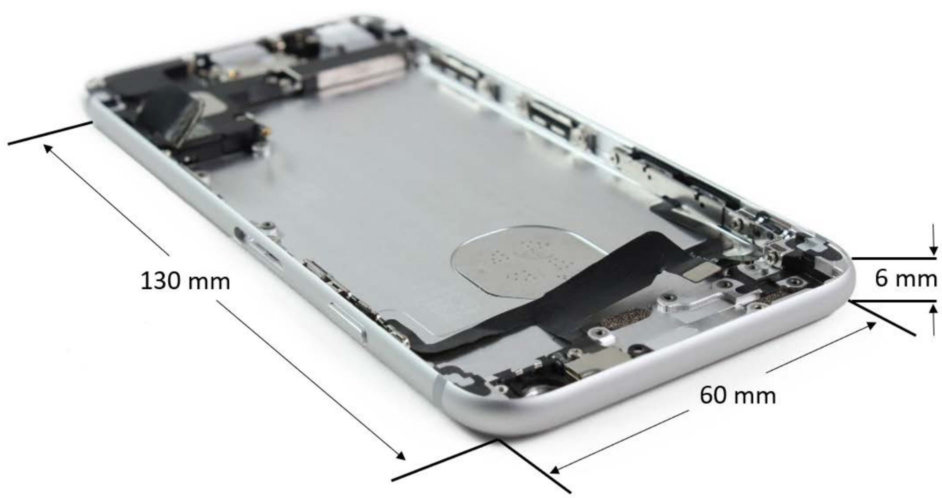
1 pt for SLA having better resolution or those materials having higher glass/melt temperatures

No points awarded for discussing issues with making the part out of 3D printing

<u>Problem 4 - Cutting</u> 24 pts total

One example of a high volume, machined consumer product was the iPhone 6 chassis, shown in the figure below:

You are tasked with machining the pocket for the chassis. For this analysis, you can simplify the geometry and features - treat this operation as milling a rectangular pocket with dimensions of 130 x 60 x 6 mm.



The part material is 6061-T6 aluminum alloy with the following properties:

- Density ρ = 2700 kg/m^3,
- Specific heat capacity = 900 J/kg·K
- Thermal diffusivity = $6.9*10^{-5}$ m^2/s
- Specific energy = 0.8 W·s/mm^3

a) You have a coated carbide end mill (3 flute) that is 6 mm in diameter and are roughing the whole depth of 6 mm in a single pass. The end mill manufacturer states that the following conditions are suitable given your tool/workpiece material combination:

- Feed = 0.2 mm/tooth
- Speed = 1400 m/min

How long would it take you to perform this machining operation, assuming you use a 100% stepover (a width of cut of 6 mm) and your machine has no limitations in it's capability?

Calculate Spindle speed from given surface speed and tool dimensions
N = V/(pi*D)
2 pts equation
N = 1400(m/min) / (pi * 0.006(m)) = **74,272 rpm (!)**
1 pt answer

Calculate feed rate (linear speed of workpiece) from spindle speed and tool
v = N * n * f
2 pts equation
v = 74,272 rpm * 3 teeth * 0.0002 m/tooth = 44.6 m/min
1 pt answer

Calculate time for operation from feed rate and MRR / dimensions
MRR = w * d * v
2 pts equation
MRR = 0.006 m * 0.006 m * 44.6 m/min = 0.001605 m^3/min
1 pt answer

MRR = volume/time
Time = volume/MRR
1 pts equation

Time = (0.130 m * 0.06 m * 0.006 m) / 0.001605 m^3/min = 0.029 min = **1.75 s !**
1 pt answer

Alternatively, students may have approximated the length of the tool path, and then divided by the feed rate (linear speed). Full credit given with this approach too

Time = length of tool path/feed rate
Time = 1.3m / (44.6 m/min) = 0.029 min = 1.75 s
11 pts total

b) In reality your mill has performance limitations. You have a HAAS VF2 mill rated at:

- Max Power = 22.4 kW (30 HP)

- Max Spindle Speed = 15,000 RPM

Is your machine capable of performing the above operation in the amount of time you calculated in part (a)?

No! The spindle speed in part a) is nearly 5x higher than the capability of the machine, so the time for the operation would be approximately 5x as much.
2 pts justification
1 pt answer
3 pts total

Calculation below not necessary, but if students wanted to check their work
Calculate feed rate
v = 15,000 * 3 teeth * 0.0002 m/tooth = 9 m/min = 0.15 m/s

Calculate time for operation from feed rate and toolpath / dimensions
Length of toolpath = 0.130 m x 10 passes = 1.3 m
Cutting time = length of toolpath / feed rate
t = 1.3 m / 9 (m/min) = 0.144 min = 8.7 s

c) With the max spindle speed from part (b), what is the power required to perform the operation?

Calculate power required
P = us * MRR
2 pts equation

Calculate MRR (use milling!)
MRR = w * d * v
2 pts equation
MRR = 6 mm * 6 mm * 150 mm/s = 5,400 mm^3/s
1 pt answer
P = 0.8 (W*s/mm^3) * 5,400 (mm^3/s) = 4.32 kW
1 pt answer
6 pts total

d) After a few highly publicized incidents of users bending their phone chassis, a design engineer suggests switching to a **titanium alloy** to improve stiffness while maintaining the same dimensions. **Qualitatively**, in 1-2 sentences, how does this change in material impact your operation time and tool requirements? Use table 24.2 from Kalpakjian below to help you with your answer.

Material	Cutting tool	General-purpose starting conditions		Range of conditions	
		Feed, mm/tooth	Speed, m/min	Feed, mm/tooth	Speed, m/min
Low-carbon and free-machining steels	Uncoated carbide, coated carbide, cermets	0.13–0.20	100–472	0.085–0.38	90–425
Alloy steels					
Soft	Uncoated, coated, cermets	0.10–0.18	100–260	0.08–0.30	60–370
Hard	Cermets, PcBN	0.10–0.15	90–220	0.08–0.25	75–460
Cast iron, gray					
Soft	Uncoated, coated, cermets, SiN	0.10–0.20	160–440	0.08–0.38	90–1370
Hard	Cermets, SiN, PcBN	0.10–0.20	120–300	0.08–0.38	90–460
Stainless steel, Austenitic	Uncoated, coated, cermets	0.13–0.18	120–370	0.08–0.38	90–500
High-temperature alloys Nickel based	Uncoated, coated, cermets, SiN, PcBN	0.10–0.18	30–370	0.08–0.38	30–550
Titanium alloys	Uncoated, coated, cermets	0.13–0.15	50–60	0.08–0.38	40–140
Aluminum alloys					
Free machining	Uncoated, coated, PCD	0.13–0.23	1200–1460	0.08–0.46	300–3000
High silicon	PCD	0.13	610	0.08–0.38	370–910
Copper alloys	Uncoated, coated, PCD PCD	0.13–0.23	300–760	0.08–0.46	90–1070
Plastics	Uncoated, coated, PCD PCD	0.13–0.23	270–460	0.08–0.46	90–1370

Source: Based on data from Kennametal, Inc.
Note: Depths of cut, *d*, usually are in the range of 1–8 mm. PcBN: polycrystalline cubic-boron nitride; PCD: polycrystalline diamond. See also Table 23.4 for range of cutting speeds within tool material groups.

The time to machine will **increase dramatically** due to the **significantly reduced surface speed** (50-60 m/min vs 1400 m/min) and the **reduced feed** (0.13-0.15 mm/tooth vs 0.2 mm/tooth). The same coated or uncoated carbide tool could be used, or a switch to cermet tooling might be beneficial.
3 pts justification
1 pt answer
4 pts total

In addition, you may need a more powerful mill to handle the increased specific cutting energy.

Students **do not** need to do the full calculation below. This is done purely for informational purposes.
Calculate Spindle speed from given surface speed and tool dimensions
Use surface speed of 50 m/min and feed of 0.13 mm/tooth

N = V/(pi*D)
N = 50(m/min) / (pi * 0.006(m)) = 2,653 rpm

Calculate feed rate (linear speed of workpiece) from spindle speed and tool
v = N * n * f
v = 2653 rpm * 3 teeth * 0.00013 m/tooth = 1 m/min

Cutting time = length of toolpath / feed rate
t = 1.3 m / 1 (m/min) = 1.3 min = 78 s

Problem 5 - Quality Control and Variation 24 pts total

a) A can carrier is defective if the cans will not snap into the carrier correctly. Assume the cans themselves have no variation. To succeed with such low profit margins, the can carrier manufacturer must have less than 5 defective parts out of every 1000. This is an idealization, as injection molding defect rates would probably be much less in practice. The target mean diameter is 60mm. The standard deviation is 0.1mm. A z-table is located in the Appendix. 17 pts

i. What are the USL and LSL? 6 pts

0.5% defect rate

Means that 0.9975 and 0.0025 are the cutoffs on the z-table.

ZUSL = 2.81 and ZLSL = -2.81

s = 0.1, xbar = 60

$$Z = \frac{x - \bar{x}}{s}$$

Z*s+xbar = x

2.81*0.1 + 60 = 60.281mm

60 - 2.81*0.1 = 59.719mm

1 pt for 0.5% defect rate

1 pt for 0.0097 and 0.0025

1 pt for z = +/- 2.81

1 pt for z equation

1 pt for calc

1 pt for USL/LSL

*If the student incorrectly did 60mm+/-0.3mm they get 2pts for equation and USL/LSL and most often will see either a -4 or -5 for the other components missed but you will get full credit for using those wrong USL/LSL through parts ii and iii before with “carry through”

ii. Calculate the process capability (Cp) needed to achieve that minimum defect rate. What does your resulting Cp suggest? 4 pts

Using USL/LSL from the previous question.

Cp = Range/6sigma = (60.281-59.719)/(6*0.1) = **0.937**

This is below our standard understanding 1.33 as a capable process or even 1.

1 pt for using previous USL/LSL and getting range

1 pt for equation

1 pt for correct answer with the 0.1 sigma

1 pt for basic interpretation (based on whatever answer they got <<1 bad, close to 1 not bad, >1 good)

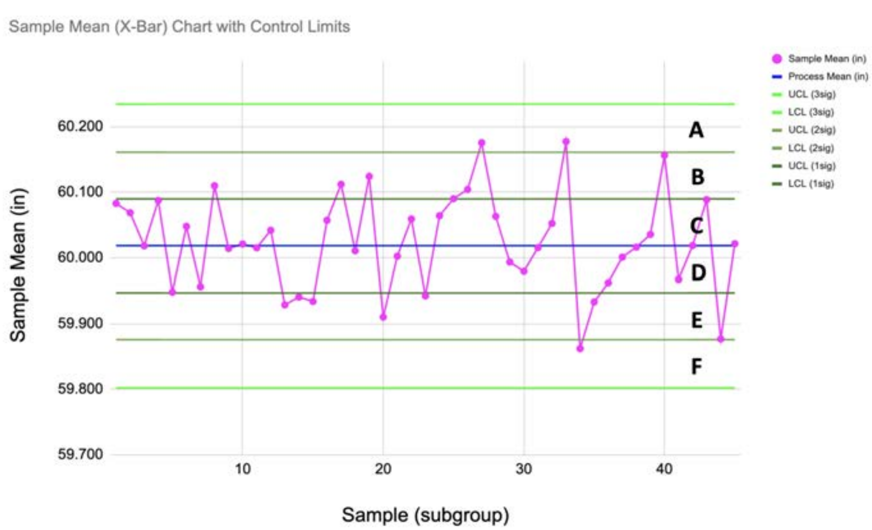
*Note that wrong USL/LSL can carry through on here with no penalty

iii. While holding the same specification limits that you calculated in part (i), what is the most that your mean diameter could increase and still be able to achieve a Cpk of 0.8? 4 pts

We know that this means our USL will be the limiting factor.
Cpk = min(USL-u, u-LSL)/3sigma = (USL-u)/3sigma
unew = USL - 3sigma*Cpk
unew = 60.281 - ((3*0.1)*0.8)
unew = 60.041
shift = unew - uold = 60.041-60 = 0.041mm
1 pt for finding min of one side for the USL/LSL (zmin)
1 pt for equation
1 pt for mean and sigma and cpk inserted (many people forgot the 0.1 sigma when rearranging)
1 pt for answer (either left in unew or fully in subtracted shift form is okay)
*Note that wrong USL/LSL can carry through on here with no penalty

iv. If the manufacturers want their process to be certified as “six-sigma” (six standard deviations between the mean and the nearest specification limit), what does this mean their Cpk is? What would be the problem of trying to use the z-tables in the Appendix to calculate the defect rate for the six-sigma case? 3 pts
Given in prompt that distance between SL and u is 6sigma
Cpk = zmin/3 = min(USL-u, u-LSL)/3sigma = 6sigma/3sigma **= 2**
The chart only goes to +/- 3sigma so it would be off the chart. It also doesn’t have the resolution necessary for such a small percentage.
1 pt for using min cpk formula
1 pt 6/3 = 2 (note: saying 1 or 1.33 is not correct)
1 pt for saying something to the effect of either off the chart or not enough resolution

b) Inspect the x-bar chart of the can carrier with process mean and control limits (UCL/LCL). 7 pts



i. Assuming your process stays in control, what % of sample averages do you expect to be in regions C+D?

68.2%, by central limit theorem and definition of normal distribution within 1 std. Dev.
1 pt for saying ~70% (or for counting the dots and dividing which is incorrect but gets you close)
1 pt for ~exact correct calculation with the z-scores or known percentages

ii. D + E + F?

99.7% / 2 = **49.85%**, by central limit theorem and definition of half a normal distribution within 3 std. dev.

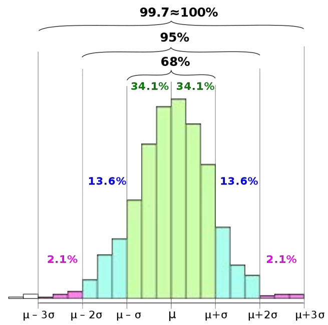
1 pt for saying ~50% (or for counting the dots and dividing which is incorrect but gets you close)
1 pt for ~exact correct calculation with z-scores or known percentages including accounting for tail

iii. F?

(99.7-95%) / 2 = **2.4925%**, by central limit theorem and definition of normal distribution between 2 and 3 std. Dev.
1 pt for saying ~2% (or for counting the dots and dividing which is incorrect but gets you close)
1 pt for ~exact correct calculation with the z-scores or known percentages

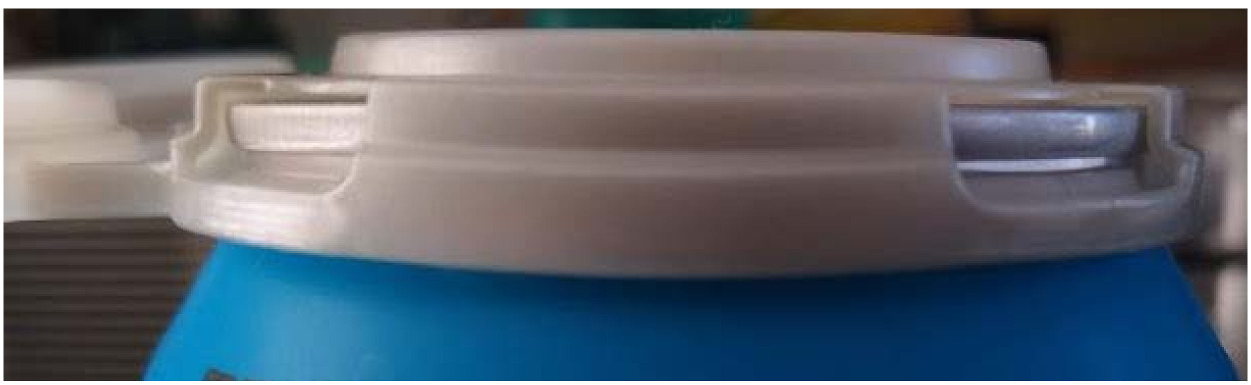
iv. How does your answer change if you identify that your process is out of control?

You can't estimate without it being in control since it relies on the standard normal and those control limits.
1 pt for saying anything related to no longer possible to estimate or things increase/decrease an unknown amount or giving an example based on mean shift in one direction or another

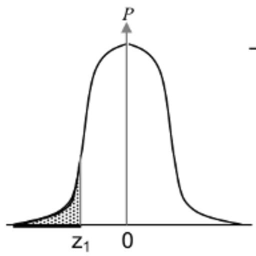


Appendix:


PATENT DETAILS:
PAKTECH-OPI.COM/PATENTS

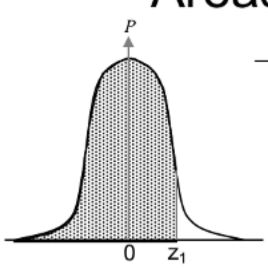


Areas under the Normal Distribution Curve



Z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
-2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
-2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
-2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
-2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
-2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
-2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
-2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
-2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
-2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
-2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
-1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
-1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
-1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
-1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
-1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
-1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
-1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
-1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
-1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
-1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
-0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
-0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
-0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
-0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
-0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
-0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359

Areas under the Normal Distribution Curve



Z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990