Below is the data given for thermal expansion coefficient of steel as a function of temperature. Solve the following problem.

Temperature			
Fahrenheit	Celsius	Kelvin	Instantaneous Thermal Expansion E-06 in / (in F)
80	26.67	299.67	6.47
60	15.56	288.56	6.36
40	4.44	277.44	6.24
20	-6.67	266.33	6.12
0	-17.78	255.22	6.00
-20	-28.89	244.11	5.86
-40	-40.00	233.00	5.72
-60	-51.11	221.89	5.58
-80	-62.22	210.78	5.43
-100	-73.33	199.67	5.28
-120	-84.44	188.56	5.09
-140	-95.56	177.44	4.91
-160	-106.67	166.33	4.72
-180	-117.78	155.22	4.52
-200	-128.89	144.11	4.30
-220	-140.00	133.00	4.08
-240	-151.11	121.89	3.83
-260	-162.22	110.78	3.58
-280	-173.33	99.67	3.33
-300	-184.44	88.56	3.07
-320	-195.56	77.44	2.76
-340	-206.67	66.33	2.45

A bascule bridge designer needs to shrink fit a solid circular shaft 'A' of diameter 12.358" in a hollow cylinder 'B' with inner diameter 12.338". His plan is to put the solid shaft 'A' in liquid nitrogen to contract its diameter so that it can be slided through the inner diameter of cylinder 'B'. He also needs a diameteral clearance of at least 0.01" so that the shafts do not touch each other before the whole shaft 'A' is slided through. Assume the room temperature is 70^{o}F and liquid nitrogen boils at -315^{o}F.

Start each part on a fresh page and write "complete sentences" and "units". Show all your work including work done in Excel , Mathcad, etc.

a) A consultant on this project assumed the thermal expansion coefficient is a constant over the temperature range. He used the value of thermal expansion coefficient at 80^{o}F in all his calculations. Find the contraction of diameter in the shaft 'A'. Does he calculate enough contraction in the shaft 'A' diameter?

b) Is his assumption of assuming constant thermal expansion correct? Why or why not? A single sentence answer will do.

c) How would you solve the problem? Solve by at least **two** different methods you learnt in class. Do you calculate enough contraction in shaft 'A' diameter?

d) If you did not get enough contraction in the diameter in part [c], what would you suggest? Give a **quantified** solution, not just a qualitative answer.