Second Semester Examination
2022/2023 Academic Session

July/August 2023

EEM421 – Quality Techniques

Duration: 2 hours

Please check that this examination paper consists of **SEVEN (7)** pages of printed material including appendix before you begin the examination.

Instructions : This paper consists of **THREE (3)** questions. Answer **ALL** questions.

1. a) Design for Manufacturing and Assembly (DFMA) is a methodology that has its roots in the early days of the industrial revolution. In the early 19th century, the standardization of parts and assembly line techniques allowed manufacturers to produce goods more efficiently and at a lower cost. However, it was not until the mid-20th century that the concept of DFMA began to take shape as a distinct methodology. In the 1950s, Dr. Boothroyd, a professor of mechanical engineering began to study the relationship between product design and manufacturing efficiency. His research showed that up to 70% of the cost of a product was determined by decisions made during the design phase. He also identified several principles that could be used to design products that were easier to manufacture and assemble. Based on the explanation of DFMA and acting as an owner of a manufacturing company.

State and briefly explain your proposal to adapt DFMA in your company by using Five (5) principles of the DFMA.

(50 marks)

b) In the early 2000s, the automotive industry was facing a major challenge with the introduction of electric vehicles (EVs). Many traditional car manufacturers were struggling to adapt to this new technology and were falling behind newer, more agile companies that were focused solely on EVs. One company that was able to successfully navigate this transition was Tesla. Tesla recognized that the traditional automotive product life cycle, which typically spans several years, was too slow for the rapidly changing EV market. Instead, Tesla adopted a much faster product life cycle that allowed them to iterate and improve their EVs much more quickly. From the tesla story above, integrate at least **five (5)** from the list of the benefits of Product Lifecycle Management to Testa continued success of being the top EV car manufacturer in the world.

(50 marks)

...3/-

2. The term "Seven Basic Quality Tools" refers to a specific set of graphical techniques that are particularly effective in addressing quality-related problems. These tools are considered basic because they are easy to use and don't require extensive statistical knowledge, making them accessible to individuals with limited formal training. Moreover, they can be applied to a wide range of quality issues, making them a versatile solution.

a) List three basic quality tools that can be used to identify the main problem of a general quality-related issue, and describe each of them.

(30 marks)

b) The G Electronic Company has developed a motion sensor for GSM-based home security systems. However, before releasing the product to the market, it must undergo quality control and testing. To estimate the duration of the "HIGH" state of the sensor when a person approaches it, an experiment has been devised. Table 2 shows the recorded durations obtained from several trials.

Table 2: Duration of “HIGH” state in seconds.

4.51	8.5	4.19	2.29
5.96	3.49	2.25	3.45
4.89	5.25	5.36	6.3
7.28	5.25	4.29	5.25
3.96	6.79	4.66	6.5
8.22	2.56	5.25	3.33
5.55	4.90	6.10	2.49
5.25	5.40	6.5	5.25
4.10	6.11	5.25	4.56
5.70	5.25	5.00	5.25

Select an appropriate basic quality tool that can assist the company in evaluating the performance of the new sensor. Then, explain how the company can leverage the data obtained from the tool to finalize its datasheet.

(35 marks)

c) The tolerance range for a capacitor is 70 pF +/- .01 pF. The current production process generates capacitors with an average of 70.001 pF and a standard deviation of 0.004 pF for the entire population. Assuming a normal distribution, determine whether the process is capable, and draw a graph representing the distribution. Calculate the proportion of capacitors that will meet the specified tolerance limits.

(35 marks)

3. a) One of the SSDs manufacturer produces about 1 million drives (cSSD) per week for quarter 1 (FY'23 Q1) with a final yield percentage of 99%. However, the final yield was drop to 97% for quarter 2 (FY'23 Q2). Several defects that contribute to this yield drop were identified and reported in Table 3.

Table 3. Reported SMT process defects

Defects	**Failure rate (%)**
Dewetting	0.20
Cold Solder	0.10
Tombstone	1.60
Drive undercut/overcut	0.05
Others	0.05

i. Construct a schematic Pareto chart for the defects in Table 3.

(20 marks)

ii. To increase the final yield percentage, the engineers focused their investigation on the highest contribution defect. As the process engineer, please analyze the possible root causes that contribute to this defect using the Ishikawa diagram.

(30 marks)

b) A manufacturer of SSDs uses surface mount technology (SMT) to assemble the electronic components onto the circuit board. One of the critical quality characteristics for the SMT process is the solder paste height, which affects the quality of the solder joint. The data on the solder paste height was collected on the last 20 production runs by the engineer. The data are shown below:

Solder Paste Height (mm): 0.45, 0.50, 0.48, 0.47, 0.51, 0.50, 0.49, 0.48, 0.47, 0.46, 0.48, 0.50, 0.49, 0.50, 0.46, 0.45, 0.49, 0.48, 0.50, 0.47

i. Create a schematic control chart for the solder paste height using a mean chart and control limits. Standard deviation: 0.02 mm.

(20 marks)

ii. Based on the control chart, does the process appear to be in control? Explain your answer.

(10 marks)

iii. Calculate the process capability index (Cpk) for the solder paste height. Is the process capable of meeting the company's specification of a solder paste height between 0.46 mm and 0.50 mm? Explain your answer.

(20 marks)

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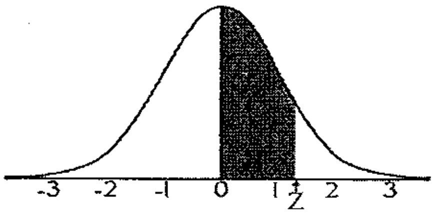
APPENDIX A



STANDARD NORMAL TABLE (Z)

Entries in the table give the area under the curve between the mean and z standard deviations above the mean. For example, for $z = 1.25$ the area under the curve between the mean (0) and z is 0.3944.

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0190	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2969	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3513	0.3554	0.3577	0.3529	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998

APPENDIX B

Course Outcomes (COs) – Programme Outcomes (POs) Mapping

Question	Course Outcome (CO)	Programme Outcome (PO)
1	2	PO7
2	4	PO3
3	3	PO2