**THE OPEN UNIVERSITY OF SRI LANKA**
**FACULTY OF ENGINEERING TECHNOLOGY**
**POSTGRADUATE DIPLOMA IN TECHNOLOGY IN INDUSTRIAL ENGINEERING – LEVEL 7**
**FINAL EXAMINATION – 2010/2011**
**MEX 7214 – QUALITY AND RELIABILITY ENGINEERING**
**DATE : *20 March 2011***
**TIME : *0930 hrs – 1230 hrs***
**DURATION: *Three (03) hours***

***Answer any five (05) questions. All questions carry equal marks. Normal Distribution Table, Coefficients for $\bar{X}$-R control charts and Exponential Distribution Table are provided.***

1. (a) Quality is a generic term which has to be defined clearly. Over the years experts and organizations have attempted to define quality. Several definitions have emerged. Discuss two such definitions. Support your answer with examples taken from products and services.

   (b) Explain how you would plan the basic steps to achieve quality starting from the definition. You may select one of the definitions to support your answer.

2. Comment on the following statements.

   (a) "Unclear, inadequate product specifications will lead to many operational problems resulting in lowering of performance."

   (b) "Standardization at national and organizational levels helps to maintain order and quality."

3. (a) Define the term "Reliability" and explain the key terms in the definition.

   (b) A washing machine requires 40 minutes to clean a load of clothes. Assuming constant failure rate, what is the reliability of the machine completing a washing cycle without failure ?

   The mean time between failure of this type of machine is 30 hours.

   (c) An item is required to have a failure rate not greater than 1.5% per 1000 hours of operation. Assuming a constant failure rate, what is the probability that one of these units will survive for a required 3000 hours of service.

4. Write an account on each of the following statements.

   (a) "Internal customer concept if practiced effectively will improve processes and strengthen relationships between employees at different levels of an organization".

   (b) "Managing an organization for quality needs to implement Total Quality Management concepts and practices".

5. A company packing fertilizer in bags has marked 50kg as the net weight for each bag. The company wishes to keep 50kg as the minimum net weight during the packing process. A study of the packing process was performed and the results revealed that the mean net weight was 50.3 kg with a standard deviation of 255g. If the weight is normally distributed, find answers to the following questions.

   (i) Does the process produce bags less than 50g? If so what percentage ?

   (ii) The company has set up an upper specification limit 51.0kg. Is the process capable of meeting this upper specification limit ?

   (iii) If the company wishes to produce at least 98% of bags above lower specification limit, what should be the mean of the packing process ?

   (iv) Under the setting given in (iii), what percentage of products will be above upper specification limit ?

6. (a) Variation in product quality is a common feature. No two products are same. They may be manufactured under same conditions, with same raw materials but they tend to differ. Write an account on how this variation occur and what actions to be taken to reduce variation.

   (b) "Statistical approach" and "Process approach" are two important aspects for maintaining and improving quality of products. Write an account in support of this statement.

7. (a) Mean-Range control chart has to be installed to a process producing metal pieces. The length of a metal piece is regarded as an important quality characteristic to be controlled. Explain briefly in a step-wise manner how you would proceed to install the control chart. If the company specification is given with the tolerance what further steps you would take to authorize the use of the control chart for future production.

(b) Control charts for mean-range are maintained for metal pieces produced by a machine. Five (5) pieces at a time were taken during the installation of the control charts. $\overline{X}$ and R values were computed for 20 sub-groups. Sum of $\overline{X}$ values was 201cm and sum of R values was 6 cm. The company specification for the metal piece is $10 \pm 0.2$ cm. According to the control chart the process is in statistical control. What is your inference regarding the use of this control chart to control future production?

8. (a) A company manufacturing liquid detergents has been facing many problems with suppliers of plastic bottles and labels. Some stocks were rejected by incoming inspection and returned to the suppliers. Relationship with suppliers is at a low level. They are becoming increasingly defensive. The company is finding it difficult to look for alternate suppliers urgently. If you are assigned the task of finding a solution to this problem, what plan of action you would suggest ?

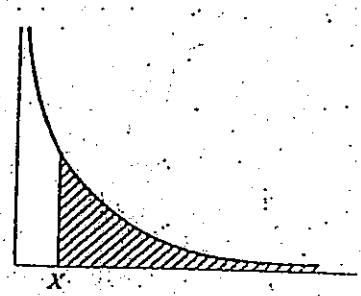
(b) Defects and errors caused by factory workers lead to many quality problems. Motivation is not the only answer to solve this problem. In depth study has to be done before deciding on remedial action. How do you approach to analyse the situation of errors and defects and what remedial actions you would suggest to minimize them?

## Coefficients for $\bar{x}$ - R charts

| Sub group Size (n) | $A_2$ | $D_3$ | $D_4$ | $d_2$ |
|---|---|---|---|---|
| 2 | 1.880 | - | 3.267 | 1.128 |
| 3 | 1.023 | - | 2.575 | 1.693 |
| 4 | 0.729 | - | 2.282 | 2.059 |
| 5 | 0.577 | - | 2.115 | 2.326 |
| 6 | 0.483 | - | 2.004 | 2.534 |
| 7 | 0.419 | 0.076 | 1.924 | 2.704 |
| 8 | 0.373 | 0.136 | 1.864 | 2.847 |
| 9 | 0.337 | 0.184 | 1.816 | 2.970 |
| 10 | 0.308 | 0.223 | 1.777 | 3.078 |

**Table B Exponential distribution values of $e^{-X/\mu}$ for various values***

Fractional parts of the total area (1.000) under the exponential curve greater than $X$. To illustrate: if $X/\mu$ is 0.45, the probability of occurrence for a value greater than $X$ is 0.6376.

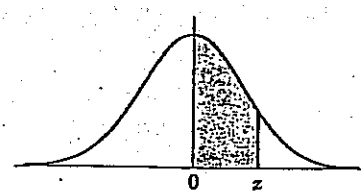



| $\frac{X}{\mu}$ | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 1.000 | 0.9900 | 0.9802 | 0.9704 | 0.9608 | 0.9512 | 0.9418 | 0.9324 | 0.9231 | 0.9139 |
| 0.1 | 0.9048 | 0.8958 | 0.8860 | 0.8781 | 0.8694 | 0.8607 | 0.8521 | 0.8437 | 0.8353 | 0.8270 |
| 0.2 | 0.8187 | 0.8106 | 0.8025 | 0.7945 | 0.7866 | 0.7788 | 0.7711 | 0.7634 | 0.7558 | 0.7483 |
| 0.3 | 0.7408 | 0.7334 | 0.7261 | 0.7189 | 0.7118 | 0.7047 | 0.6977 | 0.6907 | 0.6839 | 0.6771 |
| 0.4 | 0.6703 | 0.6637 | 0.6570 | 0.6505 | 0.6440 | 0.6376 | 0.6313 | 0.6250 | 0.6188 | 0.6126 |
| 0.5 | 0.6065 | 0.6005 | 0.5945 | 0.5886 | 0.5827 | 0.5769 | 0.5712 | 0.5655 | 0.5599 | 0.5543 |
| 0.6 | 0.5488 | 0.5434 | 0.5379 | 0.5326 | 0.5273 | 0.5220 | 0.5169 | 0.5117 | 0.5066 | 0.5016 |
| 0.7 | 0.4966 | 0.4916 | 0.4868 | 0.4819 | 0.4771 | 0.4724 | 0.4677 | 0.4630 | 0.4584 | 0.4538 |
| 0.8 | 0.4493 | 0.4449 | 0.4404 | 0.4360 | 0.4317 | 0.4274 | 0.4232 | 0.4190 | 0.4148 | 0.4107 |
| 0.9 | 0.4066 | 0.4025 | 0.3985 | 0.3946 | 0.3906 | 0.3867 | 0.3829 | 0.3791 | 0.3753 | 0.3716 |

| $\frac{X}{\mu}$ | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | 0.3679 | 0.3329 | 0.3012 | 0.2725 | 0.2466 | 0.2231 | 0.2019 | 0.1827 | 0.1653 | 0.1496 |
| 2.0 | 0.1353 | 0.1225 | 0.1108 | 0.1003 | 0.0907 | 0.0821 | 0.0743 | 0.0672 | 0.0608 | 0.0550 |
| 3.0 | 0.0498 | 0.0450 | 0.0408 | 0.0369 | 0.0334 | 0.0302 | 0.0273 | 0.0247 | 0.0224 | 0.0202 |
| 4.0 | 0.0183 | 0.0166 | 0.0150 | 0.0130 | 0.0123 | 0.0111 | 0.0101 | 0.0091 | 0.0082 | 0.0074 |
| 5.0 | 0.0067 | 0.0061 | 0.0055 | 0.0050 | 0.0045 | 0.0041 | 0.0037 | 0.0033 | 0.0030 | 0.0027 |
| 6.0 | 0.0025 | 0.0022 | 0.0020 | 0.0018 | 0.0017 | 0.0015 | 0.0014 | 0.0012 | 0.0011 | 0.0010 |

*Adapted from S. M. Selby (ed.), *CRC Standard Mathematical Tables*, 17th ed., CRC Press, Cleveland, Ohio, 1969, pp. 201–207.

# AREAS under the STANDARD NORMAL CURVE from 0 to $z$




| $z$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .0000 | .0040 | .0080 | .0120 | .0160 | .0199 | .0239 | .0279 | .0319 | .0359 |
| 0.1 | .0398 | .0438 | .0478 | .0517 | .0557 | .0596 | .0636 | .0675 | .0714 | .0754 |
| 0.2 | .0793 | .0832 | .0871 | .0910 | .0948 | .0987 | .1026 | .1064 | .1103 | .1141 |
| 0.3 | .1179 | .1217 | .1255 | .1293 | .1331 | .1368 | .1406 | .1443 | .1480 | .1517 |
| 0.4 | .1554 | .1591 | .1628 | .1664 | .1700 | .1736 | .1772 | .1808 | .1844 | .1879 |
| 0.5 | .1915 | .1950 | .1985 | .2019 | .2054 | .2088 | .2123 | .2157 | .2190 | .2224 |
| 0.6 | .2258 | .2291 | .2324 | .2357 | .2389 | .2422 | .2454 | .2486 | .2518 | .2549 |
| 0.7 | .2580 | .2612 | .2642 | .2673 | .2704 | .2734 | .2764 | .2794 | .2823 | .2852 |
| 0.8 | .2881 | .2910 | .2939 | .2967 | .2996 | .3023 | .3051 | .3078 | .3106 | .3133 |
| 0.9 | .3159 | .3186 | .3212 | .3238 | .3264 | .3289 | .3315 | .3340 | .3365 | .3389 |
| 1.0 | .3413 | .3438 | .3461 | .3485 | .3508 | .3531 | .3554 | .3577 | .3599 | .3621 |
| 1.1 | .3643 | .3665 | .3686 | .3708 | .3729 | .3749 | .3770 | .3790 | .3810 | .3830 |
| 1.2 | .3849 | .3869 | .3888 | .3907 | .3925 | .3944 | .3962 | .3980 | .3997 | .4015 |
| 1.3 | .4032 | .4049 | .4066 | .4082 | .4099 | .4115 | .4131 | .4147 | .4162 | .4177 |
| 1.4 | .4192 | .4207 | .4222 | .4236 | .4251 | .4265 | .4279 | .4292 | .4306 | .4319 |
| 1.5 | .4332 | .4345 | .4357 | .4370 | .4382 | .4394 | .4406 | .4418 | .4429 | .4441 |
| 1.6 | .4452 | .4463 | .4474 | .4484 | .4495 | .4505 | .4515 | .4525 | .4535 | .4545 |
| 1.7 | .4554 | .4564 | .4573 | .4582 | .4591 | .4599 | .4608 | .4616 | .4625 | .4633 |
| 1.8 | .4641 | .4649 | .4656 | .4664 | .4671 | .4678 | .4686 | .4693 | .4699 | .4706 |
| 1.9 | .4713 | .4719 | .4726 | .4732 | .4738 | .4744 | .4750 | .4756 | .4761 | .4767 |
| 2.0 | .4772 | .4778 | .4783 | .4788 | .4793 | .4798 | .4803 | .4808 | .4812 | .4817 |
| 2.1 | .4821 | .4826 | .4830 | .4834 | .4838 | .4842 | .4846 | .4850 | .4854 | .4857 |
| 2.2 | .4861 | .4864 | .4868 | .4871 | .4875 | .4878 | .4881 | .4884 | .4887 | .4890 |
| 2.3 | .4893 | .4896 | .4898 | .4901 | .4904 | .4906 | .4909 | .4911 | .4913 | .4916 |
| 2.4 | .4918 | .4920 | .4922 | .4925 | .4927 | .4929 | .4931 | .4932 | .4934 | .4936 |
| 2.5 | .4938 | .4940 | .4941 | .4943 | .4945 | .4946 | .4948 | .4949 | .4951 | .4952 |
| 2.6 | .4953 | .4955 | .4956 | .4957 | .4959 | .4960 | .4961 | .4962 | .4963 | .4964 |
| 2.7 | .4965 | .4966 | .4967 | .4968 | .4969 | .4970 | .4971 | .4972 | .4973 | .4974 |
| 2.8 | .4974 | .4975 | .4976 | .4977 | .4977 | .4978 | .4979 | .4979 | .4980 | .4981 |
| 2.9 | .4981 | .4982 | .4982 | .4983 | .4984 | .4984 | .4985 | .4985 | .4986 | .4986 |
| 3.0 | .4987 | .4987 | .4987 | .4988 | .4988 | .4989 | .4989 | .4989 | .4990 | .4990 |
| 3.1 | .4990 | .4991 | .4991 | .4991 | .4992 | .4992 | .4992 | .4992 | .4993 | .4993 |
| 3.2 | .4993 | .4993 | .4994 | .4994 | .4994 | .4994 | .4994 | .4995 | .4995 | .4995 |
| 3.3 | .4995 | .4995 | .4995 | .4996 | .4996 | .4996 | .4996 | .4996 | .4996 | .4997 |
| 3.4 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4998 |
| 3.5 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 |
| 3.6 | .4998 | .4998 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 |
| 3.7 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 |
| 3.8 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 |
| 3.9 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 |