UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2013/2014 Academic Session

June 2014

EPM 212 – Metrology and Quality Control
[Metrologi dan Kawalan Kualiti]

Duration : 3 hours
Masa : 3 jam

Please check that this paper contains **NINE** printed pages, **TWO** page appendix and **SIX** questions before you begin the examination.

*[Sila pastikan bahawa kertas soalan ini mengandungi **SEMBILAN** mukasurat bercetak, **DUA** mukasurat lampiran dan **ENAM** soalan sebelum anda memulakan peperiksaan.]*

Appendix/*Lampiran:*

1. **Appendix A/***Lampiran A* [1 page/mukasurat]

2. **Appendix B**/*Lampiran B:*
   Factors for constructing Variables Control Chart [1 page/mukasurat]

INSTRUCTIONS : Answer **FIVE (5)** questions.

***[ARAHAN :** Jawab **LIMA (5)** soalan.]*

You may answer all questions in **English** OR **Bahasa Malaysia** OR a combination of both.
*[Calon boleh menjawab semua soalan dalam **Bahasa Malaysia** ATAU **Bahasa Inggeris** ATAU kombinasi kedua-duanya.]*

Answer to each question must begin from a new page.
[Jawapan untuk setiap soalan mestilah dimulakan pada mukasurat yang baru.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

Q1. [a] (i) Differentiate the 'line standard' and the 'end standard' used in length measurement. Then, give THREE (3) limitations of the line standard compared to the end standard in measurement.

Bezakan 'piawai garisan' dan 'piawai hujung' yang digunakan dalam pengukuran panjang. Kemudian, berikan TIGA (3) kekangan piawai garisan berbanding dengan piawai hujung dalam pengukuran.

(20 marks/*markah*)

(ii) State THREE (3) factors that have been identified in affecting the accuracy of measuring instruments. For each factor, name TWO (2) sources of each factor.

Nyatakan TIGA (3) faktor yang telah dikenalpasti mempengaruhi ketepatan alat pengukur. Bagi setiap faktor, namakan DUA (2) punca untuk setiap faktor.

(15 marks/*markah*)

[b] A 25 m steel tape is calibrated to measure true distance when temperature is 23 °C. An architect used this tape in summer season at 38 °C and measured distance between two points was found to be 18.756 m. Given that the equation of the temperature error,

Satu pita keluli berpanjang 25 m ditentukur untuk mengukur jarak benar pada suhu 23 ° C. Seorang arkitek menggunakan pita ini pada musim panas dengan suhu 38 ° C dan jarak diukur antara dua titik adalah didapati 18.756 m. Diberi bahawa persamaan ralat suhu,

$$\Delta L = L(\alpha_1 \Delta t_1 - \alpha_2 \Delta t_2)$$

where,

di mana,

α_1 = expansion coefficient of specimen material
α_1 = *pekali pengembangan bahan specimen*
α_2 = expansion coefficient of instrument material
α_2 = *pekali pengembangan bahan alat pengukur*
Δt_1 = t_1 – temperature during calibration (°C)
Δt_1 = *t_1 – suhu semasa tentuukur (°C)*
Δt_2 = t_2 – temperature during calibration (°C)
Δt_2= *t_2 – suhu semasa tentuukur (°C)*

(i) Determine the true distance between these two points. Take the coefficient of linear expansion of the material of the steel tape to be 11.5 × 10^{-6} m/m/°C.

Tentukan jarak sebenar di antara dua titik yang diberikan. Gunakan pekali pengembangan linear bahan pita keluli ini sebagai 11.5 × 10^{-6} m / m / ° C.

(10 marks/*markah)*

(ii) Determine the percentage difference between the measured true distances of these two points if the architect repeated the measurement in winter season with the ambient temperature was -5 °C.

Tentukan perbezaan peratusan antara jarak sebenar yang diukur di antara dua titik jika arkitek ini berulang ukuran ini pada musim sejuk dengan suhu sekitar adalah -5 ° C.

(15 marks /*markah*)

[c] State FOUR (4) common amplification mechanisms used in precision instruments. For each amplification mechanism, give ONE (1) example of the measuring instrument.

Nyatakan EMPAT (4) mekanisme amplifikasi yang biasa digunakan dalam alat pengukur persis. Bagi setiap mekanisme amplifikasi, berikan SATU (1) contoh alat pengukur.

(20 marks / *markah)*

[d] Two accurately machined circular rollers *A* and *B* were tested for dimensional accuracy using the interferometry technique by viewing the optical fringes on the flat glass plate using the cadmium red light of wavelength 0.664 μm. If 14 fringes were observed in a distance, *x, as* shown in the Figure 1[d] below, determine the difference in diameter of circular cylinder.

Dua penggelek bulatan A dan B yang tepat dimesin telah diuji ketepatan dimensinya dengan menggunakan teknik interferometri dengan melihat jeriji optik pada plat kaca rata dengan menggunakan cahaya merah kadmium yang panjang gelombangnya 0.664 μm. Jika 14 jeriji dapat dilihat pada jarak x yang ditunjukkan dalam Rajah 1[d] di bawah, tentukan perbezaan diameter silinder bulat.

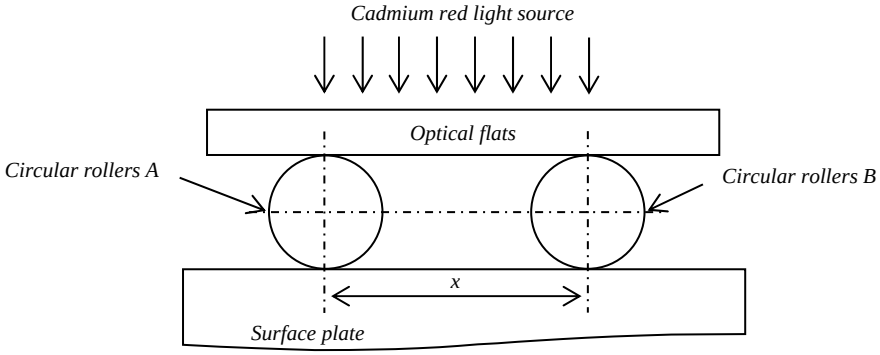


Figure 1[d]
Rajah 1[d]

(20 marks/*markah)*

Q2. [a] (i) Explain the difference of the alignment test for the machine tools under 'static condition' and 'dynamic condition'. Give THREE (3) types of alignment test for each condition.

Terangkan perbezaan ujian penjajaran untuk peralatan mesin di bawah 'keadaan statik' dan 'keadaan dinamik'. Berikan TIGA (3) jenis ujian penjajaran bagi setiap keadaan.

(25 marks/*markah)*

(ii) With appropriate sketch and label, describe a perpendicularity test of the spindle and table performed on a drilling machine using a dial gage.

Dengan lakaran dan label yang sesuai, terangkan ujian ketegakan antara gelendong dan meja yang dilakukan ke atas mesin gerudi dengan menggunakan tolok dial.

(25 marks/*markah*)

[b] Explain the difference between measured features and constructed features in relation to a coordinate measuring machine (CMM). Give THREE (3) examples of each type of feature.

Terangkan perbezaan antara ciri-ciri diukur dan ciri-ciri dibina berhubung dengan mesin mengukur koordinat (CMM). Berikan TIGA(3) contoh bagi setiap jenis ciri.

(20 marks/*markah)*

[c] Give ONE (1) advantage and ONE (1) disadvantage of the following types of coordinate measuring machine (CMM):

(i) Horizontal arm CMM
(ii) Bridge type CMM
(iii) Gantry type CMM

Berikan SATU (1) kelebihan dan SATU (1) kelemahan bagi setiap jenis mesin mengukur koordinat (CMM) berikut:

(i) CMM lengan mendatar
(ii) CMM jenis tetimbang
(iii) CMM jenis gantri

(30 marks/*markah)*

Q3. [a] Explain the difference between roughness and waviness. Illustrate with sketches.

Terangkan perbezaan antara kekasaran dan kealunan. Ilustrasi dengan lakaran.

(10 marks/*markah)*

[b] The skewness parameter (R_{sk}) of a surface is given by the following expression:

Parameter kepencongan (R_{sk}) bagi suatu permukaan diberikan oleh ungkapan berikut:

$$R_{sk} = \frac{1}{nR_q^3}\sum_{i=1}^{n} y_i^3$$

Sketch the profiles (traces) to show surfaces that have: (i) approximately zero skewness, (ii) positive skewness and (iii) negative skewness. Give ONE(1) practical application of a surface that has negative skewness.

Lakar profil (surihan) untuk menunjukkan permukaan yang mempunyai: (i) kepencongan sifar, (ii) kepencongan positif, dan (iii) kepencongan negatif. Berikan SATU(1) aplikasi praktik bagi permukaan yang mempunyai kepencongan negatif.

(15 marks/*markah)*

[c] What is meant by roundness error? Figure Q3[c] in Appendix A shows a trace on a grid whose spacing is 5 μm. Determine the roundness error of the trace based on

(i) Least Square Circle (LSC) method
(ii) Minimum Circumscribing Circle (MCC) method
(iii) Maximum Inscribing Circle (MIC) method

Note: Attach Appendix A with your answer script.

Apakah yang dimaksudkan dengan 'ralat kebulatan'? Rajah S3[c] dalam Lampiran A menunjukkan surihan pada grid berjarak 5 μm. Tentukan ralat kebulatan surihan tersebut berasaskan:

(i) Kaedah 'Least Square Circle'
(ii) Kaedah 'Minimum Circumscribing Circle'
(iii) Kaedah 'Maximum Inscribing Circle'

Nota: Kepilkan Lampiran A bersama skrip jawapan anda.

(55 marks/*markah)*

[d] Explain the difference between maximum material condition (MMC) and least material condition (LMC) used in GD&T.

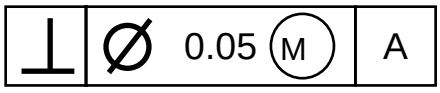
Terangkan perbezaan antara keadaan bahan maksimum (MMC) dan keadaan bahan paling kurang (LMC) yang digunakan dalam GD&T.

(10 marks/*markah)*

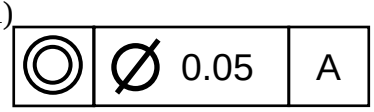
[e] Describe the type of tolerance control shown by the following tolerance symbols:

Terangkan jenis kawalan toleransi yang ditunjukkan oleh setiap simbol toleransi berikut:

(i)



(ii)



(10 marks/*markah)*

Q4. [a] (i) Compare and differentiate between the principles of Juran, Deming and Taguchi in quality control perspective?

Bandingkan dan bezakan prinsip-prinsip Juran, Deming dan Taguchi dalam perspektif kawalan mutu?

(ii) Discuss how information technology could improve quality?

Bincangkan bagaimana teknologi maklumat dapat meningkatkan kualiti?

(**30 marks**/*markah*)

[b] The following data of fracture stress and hardness (fracture stress, hardness) are for recycled aluminium cast. Construct a scatter diagram and determine the relationship.

Data yang di bawah menunjukkan tegasan patah dan kekerasan (tegasan patah, kekerasan) penuangan beracuan aluminum kitar semula. Bina rajah serakan dan dapatkan hubungkait antara keduanya.

(349,70), (368,40), (301,55), (340,78), (308,64),
(348,86), (354,71), (313,53), (322,82), (334,67),
(292,51), (377,70), (247,56), (298,60), (287,72),
(345,88), (380,95), (257,51), (258,75) (293,53).

(**30 marks**/*markah*)

[c] Specification of the elongation of a product is 9 $\pm$ 1mm. Fifty samples are tested randomly in order to estimate their process capabilities. The data are given in Table Q4[c]. From the analysed data, it is given that the subgroup size is 4, with A_2 =0.729, D_3=0 and D_4=2.282.

Spesifikasi kepanjangan sebuah produk ialah 9 $\pm$ 1mm. Lima puluh sampel diuji secara rawak untuk menganggarkan keupayaan proses. Data diberikan dalam Jadual S4[c]. Berpandukan analisa data, diberi sub-kumpulan bersaiz 4, dengan A_2 =0.729, D_3=0 and D_4=2.282.

(i) Estimate the potential capability and true process capability.

Anggarkan potensi keupayaan dan keupayaan sebenar proses tersebut.

(ii) Determine percentage defect expected, it is also given that values of Z=-2.5, Area$_1$=0.0062 and Z=-2.4, Area$_1$ = 0.0082 and Z=-2.83, Area$_1$= 0.0023

Kirakan peratusan kecacatan yang dijangkakan, diberikan juga nilai-nilai Z=-2.5, Luas$_1$=0.0062 and Z=-2.4, Luas$_1$ = 0.0082 dan Z=-2.83, Luas$_1$= 0.0023.

Table Q4[c]
Jadual S4[c]

9.5	9.2	9.1	9.3	9.7
10.1	8.9	10.0	9.3	9.6
10.0	8.7	9.4	9.5	9.7
9.2	9.1	9.7	10.1	9.6
9.7	9.2	10.0	9.7	9.8
9.8	9.3	9.3	9.1	9.3
10.0	9.2	9.3	9.4	9.5
9.1	9.1	9.5	9.4	9.3
9.5	8.9	9.0	9.0	8.9
8.9	9.7	9.5	9.0	9.6

(**40 marks**/*markah*)

Q5. **[a] State TWO (2) types and TWO (2) purposes of**
(i) Control chart.
(ii) Acceptance Sampling.

Nyatakan DUA (2) jenis dan DUA (2) tujuan
(i) Carta kawalan.
(ii) Pensampelan penerimaan.

*(***40 marks***/markah)*

[b] Table Q5[b] shows measurement data of material removal rate (mg/s). The operational data is assumed to be in control.

Jadual S5[b] menunjukkan data ukuran kadar pembuangan bahan (mg/s). Diandaikan data operasi berada dalam kawalan.

Table Q5[b
Jadual S5[b]

Sample Numbers *Bilangan Sample*	n_1	n_2	n_3	n_4	n_5
1	28.495	28.505	28.500	28.500	28.500
2	29.495	28.945	29.500	29.505	29.605
3	30.000	30.500	30.505	30.475	30.495
4	31.500	31.500	31.505	31.475	31.495
5	32.500	32.505	32.500	32.450	32.495

(i) Determine R, $\bar{x}$, $\bar{R}$ and $\bar{\bar{X}}$ control charts for the process data

Dapatkan R, $\bar{x}$, $\bar{R}$ dan $\bar{\bar{X}}$ carta kawalan untuk proses data.

(ii) Using Appendix B, calculate the centerlines and control limits for the control charts.

Berdasarkan Lampiran B, kirakan garistengah dan had kawalan bagi carta kawalan.

(iii) Suppose that these data is uncontrolled, give the most appropriate assignable causes and set up the new revised control chart with n=3.

Diandaikan bahawa data ini adalah di luar kawalan, berikan sebab musabab umpuk dan perbaiki semula carta kawalan baru dengan nilai n=3.

(**60 marks** /*markah*)

Q6. [a] Discuss the pros and cons of using acceptance sampling procedures compared to 100 percent examination.

Bincangkan kebaikan dan keburukan menggunakan tatacara penerimaan pengsampelan berbanding menjalani pemeriksaan 100 peratus.

(**30 marks** /*markah*)

[b] Describe TWO important features shown by the operating characteristics (OC) curve.

Nyatakan DUA maklumat penting yang ditunjukkan oleh lengkung cirri-ciri pengoperasian (OC).

(30 marks /*markah*)

[c] Make a comparison between single, chain and sequential sampling with OC curves.

Bandingkan di antara sampling sendirian, rantaian dan urutan menggunakan graf OC.

(40 marks /*markah*)

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