



UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2011 SESSION

SUBJECT CODE : FGD 12102
SUBJECT TITLE : METROLOGY
LEVEL : DIPLOMA
TIME / DURATION : 3.30pm – 5.30pm
(2 HOURS)
DATE : 10 MAY 2011

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. Answer ALL questions in Section A. For Section B answer only (3) questions.
6. Answer all questions in English.
7. Tolerance Grade Table is appended (Appendix)

THERE ARE 10 PRINTED PAGES OF QUESTIONS, AND 2 PAGES OF TOLERANCE TABLE
EXCLUDING THIS PAGE.

SECTION A (Total: 25 marks)**INSTRUCTION: Answer ALL questions.****Please use the objective answer sheet as provided.**

1. According to Ancient Greek, metrology is defined as,
 - A. Science of Measurement
 - B. Measurement of Science
 - C. Study of Measure
 - D. Measure of Study

2. The correct physical quantity for temperature (i.e. thermodynamic) in Metric System (SI Unit) is,
 - A. Celcius
 - B. Kelvin
 - C. Fahrenheit
 - D. Watts

3. What was the main problem with early methods (i.e. in ancient Egypt etc) related to the measurement systems?
 - A. Same method of measuring the same thing
 - B. Measures were not standardized
 - C. Complex standards being used
 - D. The use of official system of measurement units

4. The ability of two or more operators to obtain consistent results repeatedly when measuring the same set of parts and the same measuring instruments is called,
 - A. Accuracy
 - B. Precision
 - C. Reliability
 - D. Validity

5. Accuracy maybe defined is several ways. Which of the following is correct?
 - A. Accuracy is the measure of precision
 - B. Accuracy is the measure of conformity
 - C. Accuracy is the measure of reliability
 - D. Accuracy is the measure of validity

6. Which of the following terms relates most closely to precision?
- A. Closeness of tolerance
 - B. The number of measurements within a specified standard
 - C. Ratio of correct to incorrect readings
 - D. Refinement of measurement readings
7. Type of GD&T control for form includes:
- A. Profile of a Line, Circular Runout, Total Runout
 - B. Straightness, Flatness, Roundness
 - C. Angularity, Perpendicularity, Parallelism
 - D. Position, Concentricity, Symmetry
8. Steel rulers are not recommended for control of high production. Which of the following is the best explanation for this?
- A. They do not have sufficient accuracy for most production
 - B. They are more subject to instrumental error than most instruments
 - C. They are insufficient reliable and less precision
 - D. They are more low cost and easy to be used
9. Which of the following describes the parallax error?
- A. It is another name for the instrumental error
 - B. It is the apparent shifting of an object when the position of the observer is changed.
 - C. It is an error caused by the distance between the scale and the feature being measured.
 - D. It is the difference in measurement that occurs when the object is viewed from the left instead of the right or vice versa
10. Which of the following methods is the best way to eliminate parallax error?
- A. Close one eye when taking the measurement
 - B. Align the instrument so that the scale being read is along the line of measurement.
 - C. Take the measurement in various angles
 - D. Take the measurements first from one side, then from the other side, and then average them.

11. Some calipers have clamp screw so that they maybe locked to a fixed opening. Which of the following best describes the proper use of this feature?
- A. It keeps them from opening up when not in use
 - B. It provides a memory of the last measurement
 - C. It enables them to be used as snap gauges
 - D. It prevents the measurement from being lost if the caliper is dropped
12. Which of the following is the greatest limitation of vernier height gauge?
- A. Accuracy of the column scale
 - B. Low amplification of vernier instruments
 - C. Wear of base
 - D. Lack of stability
13. What is the major advantage of the micrometer over the vernier caliper?
- A. Easier to carry
 - B. Greater precision
 - C. Easier to read
 - D. More accuracy
14. One limitation of micrometer is,
- A. Suitable for end measurement only
 - B. Require oiling during use
 - C. Need temperature control of frame
 - D. Short measuring range
15. The primary purpose of wringing the gauge blocks is to:
- A. Remove air from between them
 - B. Clean them
 - C. Calibrate them
 - D. Detect cracks in them
16. Which of the following people is generally credited with having the greatest influence on gauge blocks?
- A. Hjalmar Ellstrom
 - B. Henry Ford
 - C. Eli Whitney
 - D. Carl Edvard Johansson

17. Which of the following is the best criterion for the selection of a set of gauge blocks?
- A. Lowest overall price
 - B. Lowest price per block
 - C. Sufficient range to provide one group of blocks for every dimension likely to be used.
 - D. Best cost-effectiveness based on the number of people who maybe making up similar measurements at the same time.
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18. When compared to other methods of measurement, which of the following is the main advantage of gauge blocks?
- A. Gauge blocks are self-calibrating
 - B. Gauge blocks methods are relatively slow
 - C. Gauge blocks provide better precision and reliability
 - D. Gauge blocks methods have a longer range
19. What other terms are used for pneumatic gauging?
- A. Hole gauging
 - B. Air gauging
 - C. Coordinate gauging
 - D. Feeler gauging
20. Which of the following is the primary purpose of calibration?
- A. To detect wear and adjustment malfunctions of the instruments
 - B. To determine whether or not an instrument that is inadequate for the requirement is being used.
 - C. To detect errors due to parallax and other careless procedures
 - D. To determine the adherence of an instrument or process to standards
21. What is the basic principle of calibration?
- A. Comparison with a higher standard
 - B. Examination of repetitive measurements
 - C. Measurement under constant temperature conditions
 - D. Use of high precision equipments

22. What is a Universal Bevel Protractor?
- A. Any instrument that measures all bevels
 - B. A protractor with a vernier scale and adjustable blades
 - C. A combined protractor and linear measuring instruments
 - D. An instrument that can be used either gauge blocks or vernier scale to measure angles.
23. What is the limitation of a Universal Bevel Protractor?
- A. Measure acute angles only
 - B. Measures obtuse angle only
 - C. Discrimination of 5 minutes
 - D. Discrimination of between 30 seconds to 10 minutes
24. Which of the following is the best description of sine bar?
- A. It is a steel bar that holds cylinders at an accurate spacing
 - B. It is a hypotenuse in physical form of steel bar that can be set up with various sine lengths to form angles.
 - C. It is the combination of a sine instrument, gauge blocks and surface granite table.
 - D. It is a bar that always holds cylinders at 100mm centers
25. Which of the following designation/occupational title in the manufacturing industry most likely dealt with metrology in their daily job?
- A. Forklift Driver
 - B. Material Handler
 - C. Store Keeper
 - D. QC Inspector

SECTION B (Total: 75 marks)

INSTRUCTION: Answer only THREE questions.

Please use the answer booklet as provided.

Question 1

- (a) Determine the measurement reading for angularity by the following metrological instrument as illustrated in Figure 1.1:

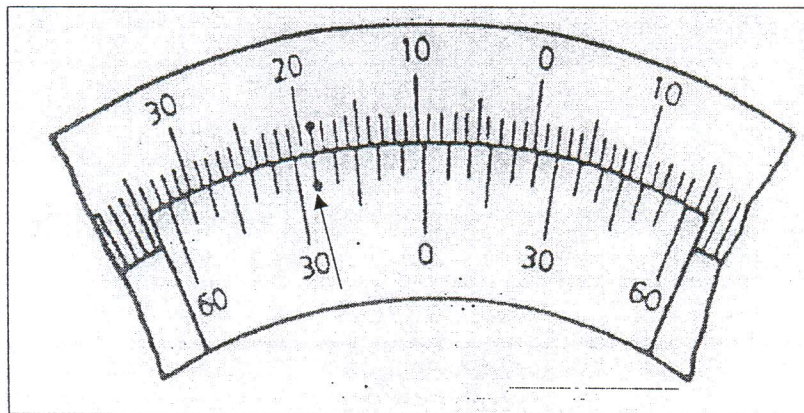


Figure 1.1: Universal Bevel Protractor

(4 marks)

- (b) Determine the measurement reading for linearity by the following metrological instrument as illustrated in Figure 1.2:

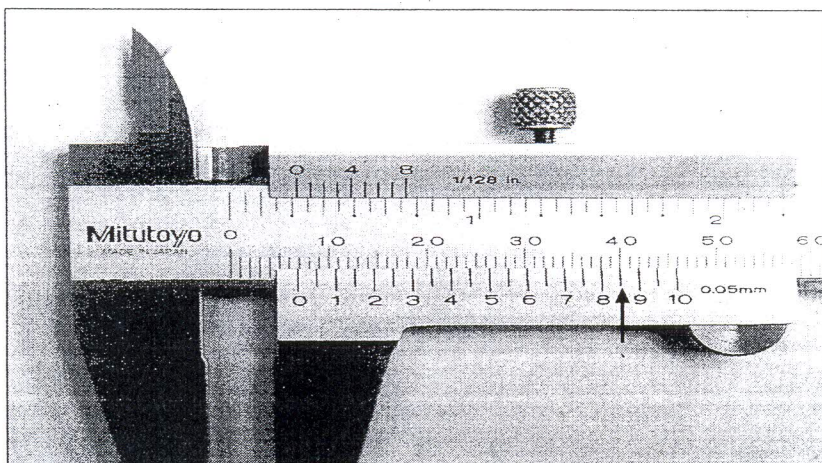


Figure 1.2: Vernier Caliper (Range: 0 ~ 150mm; Accuracy: 0.05mm)

(4 marks)

- (c) Determine the measurement reading for linearity by the following metrological instruments as illustrated in Figure 1.3:

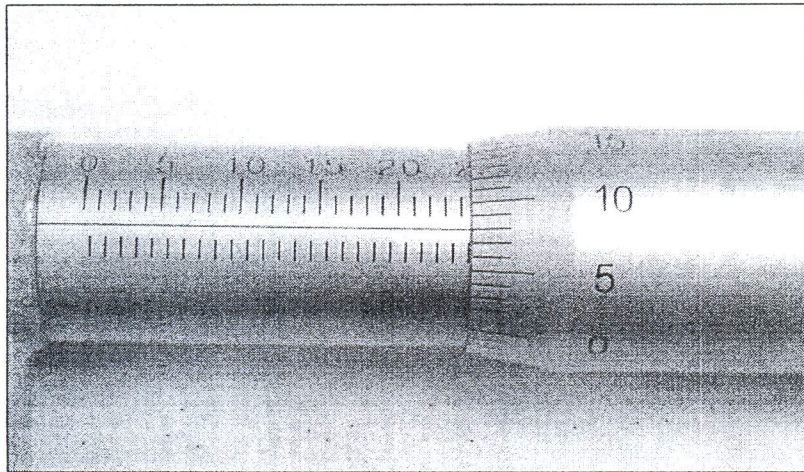


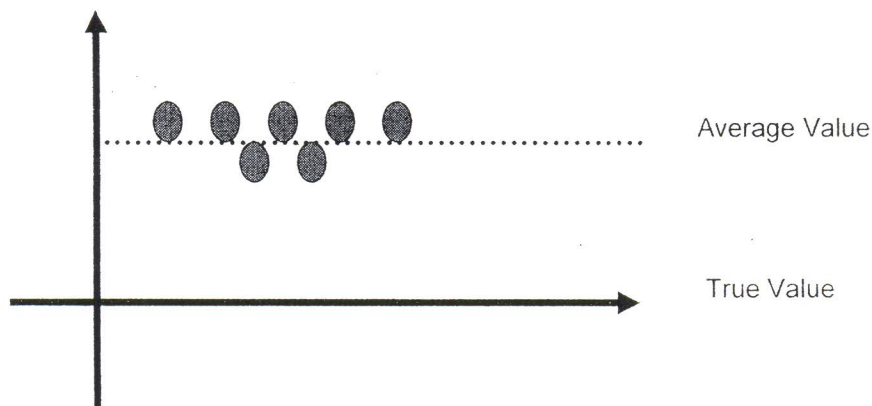
Figure 1.3: External Micrometer (Range: 0 ~ 25mm; Accuracy: 0.01mm)

(4 marks)

- (d) Rearrange these instruments with the most to the least precision according to the Hierarchy of Physical Measurement Standards: vernier caliper, micrometer, gauge blocks and steel ruler.

(4 marks)

- (e) The following Figure 1.4 illustrates the measurement results of a work piece by using typical metrological equipment. Describe the precision of the metrological equipment and the accuracy of the measurement results.



Legend

● : Measurement Results

Figure 1.4: Measurement Results

(6 marks)

- (f) Determine the type of GD&T control and its geometric characteristic in the following drawing as illustrated in Figure 1.5:

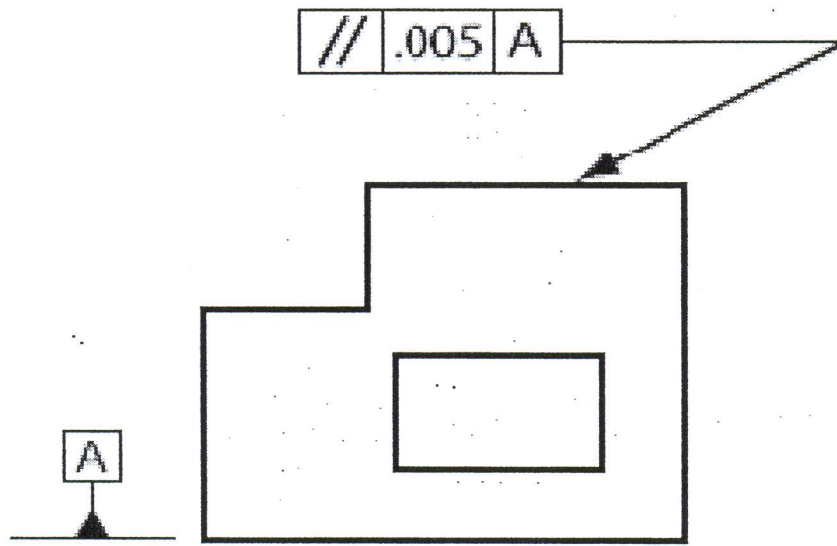


Figure 1.5: Drawing with the use of GD&T Symbols

Type of GD&T: _____; Characteristics: _____ (3 marks)

Question 2

Use Table 2.1 and 2.2 to answer the following questions:

Table 2.1: Types of Equipments

| Equip. No | Equipment | Measuring Range | Measuring Accuracy |
|-----------|----------------------|-----------------|--------------------|
| 1 | Vernier Caliper | 0 – 200 mm | 0.02 mm |
| 2 | Vernier Caliper | 0 – 250 mm | 0.02 mm |
| 3 | External Micrometer | 0 – 25 mm | 0.01 mm |
| 4 | External Micrometer | 25 – 50 mm | 0.01 mm |
| 5 | Digital Height Gauge | 0 – 300 mm | 0.01 mm |
| 6 | Gauge Blocks Set | 0 – 100 mm | 0.001 mm |

Table 2.2: Types of Work pieces

| Work piece | Feature | Max Dimension | Std Tolerance |
|------------|---------------------------------|-----------------|---------------|
| A | Cylinder (i.e. Piston) | $\Phi 40$ mm | ± 0.01 mm |
| B | Shaft (i.e. Cam Shaft) | $\Phi 15$ mm | ± 0.05 mm |
| C | Round (i.e. Ball Bearing) | $\Phi 100$ mm | ± 0.02 mm |
| D | Rectangular (i.e. Engine Block) | Length = 240 mm | ± 0.04 mm |
| E | Hole (Blind) | Depth = 50 mm | ± 0.02 mm |
| F | Rectangular Part | Height = 150 mm | ± 0.04 mm |
| G | Hole | $\Phi 10$ mm | ± 0.04 mm |
| H | Rectangular Block | Height = 50 mm | ± 0.03 mm |

- (a) Select the appropriate equipment (s) in Table 2.1 that can be used to measure the dimension for each work piece A ~ H in Table 2.2.

(16 marks)

- (b) Indicate rating or ranking of the accuracy and precision for the equipments in Table 2.1 with "Best", "Moderate" or "Poor".

(9 marks)

Question 3

Describe and give an example for each of the following principal terms used by the LIMITS and FITS:

- (a) Maximum limit size

(5 marks)

- (b) Nominal size

(5 marks)

- (c) Tolerance

(5 marks)

- (d) Maximum Material Condition (MMC)

(5 marks)

- (e) Least Material Condition (LMC)

(5 marks)

Question 4

Determine the 'Close running' tolerances for a shaft and hole that have a basic diameter of 122 mm. The specification is **122 H8 / 122 f7**. Find:

- i. Maximum clearance (4 marks)
- ii. Define the specification (5 marks)
- iii. Minimum clearance (4 marks)

| | Hole | Shaft |
|-----------------|------|-------|
| Tolerance Grade | | |
| Upper deviation | | |
| Lower deviation | | |
| Max Diameter | | |
| Min Diameter | | |
| Ave Diameter | | |

(12 marks)

END OF QUESTION

TOLERANCE GRADE TABLE (Appendix)

| BASIC SIZE | TOLERANCE GRADE | | | | | | | | | | |
|------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | IT 6 | IT 7 | IT 8 | IT 9 | IT 10 | IT 11 | IT 12 | IT 13 | IT 14 | IT 15 | IT 16 |
| 0-3 | 0.006 | 0.010 | 0.014 | 0.025 | 0.040 | 0.060 | 0.090 | 0.150 | 0.250 | 0.400 | 0.630 |
| 3-6 | 0.008 | 0.012 | 0.018 | 0.030 | 0.048 | 0.075 | 0.110 | 0.180 | 0.280 | 0.450 | 0.700 |
| 6-10 | 0.009 | 0.015 | 0.022 | 0.036 | 0.058 | 0.090 | 0.140 | 0.220 | 0.350 | 0.550 | 0.850 |
| 10-18 | 0.011 | 0.018 | 0.027 | 0.043 | 0.070 | 0.110 | 0.170 | 0.260 | 0.400 | 0.600 | 0.900 |
| 18-30 | 0.013 | 0.021 | 0.033 | 0.052 | 0.084 | 0.130 | 0.200 | 0.300 | 0.450 | 0.680 | 1.000 |
| 30-50 | 0.016 | 0.025 | 0.039 | 0.062 | 0.100 | 0.160 | 0.240 | 0.360 | 0.540 | 0.800 | 1.200 |
| 50-80 | 0.019 | 0.030 | 0.046 | 0.074 | 0.120 | 0.190 | 0.280 | 0.420 | 0.630 | 0.950 | 1.400 |
| 80-120 | 0.022 | 0.350 | 0.054 | 0.087 | 0.140 | 0.220 | 0.330 | 0.500 | 0.750 | 1.100 | 1.600 |
| 120-180 | 0.025 | 0.040 | 0.063 | 0.100 | 0.160 | 0.250 | 0.380 | 0.560 | 0.850 | 1.250 | 1.800 |
| 180-250 | 0.029 | 0.046 | 0.072 | 0.115 | 0.185 | 0.290 | 0.430 | 0.650 | 0.980 | 1.450 | 2.100 |
| 250-315 | 0.032 | 0.052 | 0.081 | 0.130 | 0.210 | 0.320 | 0.480 | 0.720 | 1.100 | 1.600 | 2.300 |
| 315-400 | 0.036 | 0.057 | 0.089 | 0.140 | 0.230 | 0.360 | 0.530 | 0.800 | 1.200 | 1.750 | 2.600 |

Source : Preferred Metric Limits and Fits , ANSI B4.2-1978. See also BSI 4500

FUNDAMENTAL DEVIATIONS FOR SHAFTS

| BASIC SIZE | UPPER DEVIATION LETTER | | | | | | | LOWER DEVIATION LETTER | | | | | | |
|------------|------------------------|--------|--------|--------|---|--------|--------|------------------------|--------|--------|--|--|--|--|
| | c | d | f | g | h | k | n | p | s | u | | | | |
| 0-3 | -0.060 | -0.020 | -0.006 | -0.002 | 0 | 0.000 | +0.004 | +0.006 | +0.014 | +0.018 | | | | |
| 3-6 | -0.070 | -0.030 | -0.010 | -0.004 | 0 | +0.001 | +0.008 | +0.012 | +0.019 | +0.023 | | | | |
| 6-10 | -0.080 | -0.040 | -0.013 | -0.005 | 0 | +0.001 | +0.010 | +0.015 | +0.023 | +0.029 | | | | |
| 10-14 | -0.095 | -0.050 | -0.016 | -0.006 | 0 | +0.001 | +0.012 | +0.018 | +0.028 | +0.033 | | | | |
| 14-18 | -0.095 | -0.050 | -0.016 | -0.006 | 0 | +0.001 | +0.012 | +0.018 | +0.028 | +0.033 | | | | |
| 18-24 | -0.110 | -0.065 | -0.020 | -0.007 | 0 | +0.002 | +0.015 | +0.022 | +0.035 | +0.041 | | | | |
| 24-30 | -0.110 | -0.065 | -0.020 | -0.007 | 0 | +0.002 | +0.015 | +0.022 | +0.035 | +0.048 | | | | |
| 30-40 | -0.120 | -0.080 | -0.025 | -0.009 | 0 | +0.002 | +0.017 | +0.026 | +0.043 | +0.060 | | | | |
| 40-50 | -0.130 | -0.080 | -0.025 | -0.009 | 0 | +0.002 | +0.017 | +0.026 | +0.043 | +0.070 | | | | |
| 50-65 | -0.140 | -0.100 | -0.030 | -0.010 | 0 | +0.002 | +0.020 | +0.032 | +0.053 | +0.087 | | | | |
| 65-80 | -0.150 | -0.100 | -0.030 | -0.010 | 0 | +0.002 | +0.020 | +0.032 | +0.059 | +0.102 | | | | |
| 80-100 | -0.170 | -0.120 | -0.036 | -0.012 | 0 | +0.003 | +0.023 | +0.037 | +0.071 | +0.124 | | | | |
| 100-120 | -0.180 | -0.120 | -0.036 | -0.012 | 0 | +0.003 | +0.023 | +0.037 | +0.079 | +0.144 | | | | |
| 120-140 | -0.200 | -0.145 | -0.043 | -0.014 | 0 | +0.003 | +0.027 | +0.043 | +0.092 | +0.170 | | | | |
| 140-160 | -0.210 | -0.145 | -0.043 | -0.014 | 0 | +0.003 | +0.027 | +0.043 | +0.100 | +0.190 | | | | |
| 160-180 | -0.230 | -0.145 | -0.043 | -0.014 | 0 | +0.003 | +0.031 | +0.050 | +0.108 | +0.210 | | | | |
| 180-200 | -0.240 | -0.170 | -0.050 | -0.015 | 0 | +0.004 | +0.031 | +0.050 | +0.122 | +0.236 | | | | |
| 200-225 | -0.260 | -0.170 | -0.050 | -0.015 | 0 | +0.004 | +0.031 | +0.050 | +0.130 | +0.258 | | | | |
| 225-250 | -0.280 | -0.170 | -0.050 | -0.015 | 0 | +0.004 | +0.031 | +0.050 | +0.140 | +0.284 | | | | |
| 250-280 | -0.300 | -0.190 | -0.056 | -0.017 | 0 | +0.004 | +0.034 | +0.056 | +0.158 | +0.315 | | | | |
| 280-315 | -0.330 | -0.190 | -0.056 | -0.017 | 0 | +0.004 | +0.034 | +0.056 | +0.170 | +0.350 | | | | |
| 315-355 | -0.360 | -0.210 | -0.062 | -0.018 | 0 | +0.004 | +0.037 | +0.062 | +0.190 | +0.390 | | | | |
| 355-400 | -0.400 | -0.210 | -0.062 | -0.018 | 0 | +0.004 | +0.037 | +0.062 | +0.208 | +0.435 | | | | |

Source : Preferred Metric Limits and Fits, ANSI B4.2-1978. See also BSI 450