UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF INDUSTRIAL TECHNOLOGY

FINAL EXAMINATION

JANUARY 2016 SEMESTER

COURSE CODE	:	JQB 20203
COURSE TITLE	:	METROLOGY
PROGRAMME LEVEL	:	BACHELOR
DATE	:	30 MAY 2016
TIME	:	9.00 AM – 12.00 PM
DURATION	:	3 HOURS

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. This question paper consists of ONE (1) sections.
4. Answer FOUR (4) questions ONLY.
5. Please write your answers on the answer booklet provided.
6. Please answer all questions in English only.

THERE ARE 8 PAGES OF QUESTIONS EXCLUDING THIS PAGE.

(Total: 100 marks)

INSTRUCTION: Answer FOUR (4) questions only.
Please use the answer booklet provided

Question 1

(a) Define the term of metrology and list **TWO (2)** importance of metrology in any industry.

(5 marks)

(b) Discuss **THREE (3)** precautions to be taken while measuring using Vernier caliper and Micrometer to minimize errors.

(6 marks)

(c) Analyze the following diagram, then sketch the correct position of Vernier caliper while taking a measurement.

(8 marks)

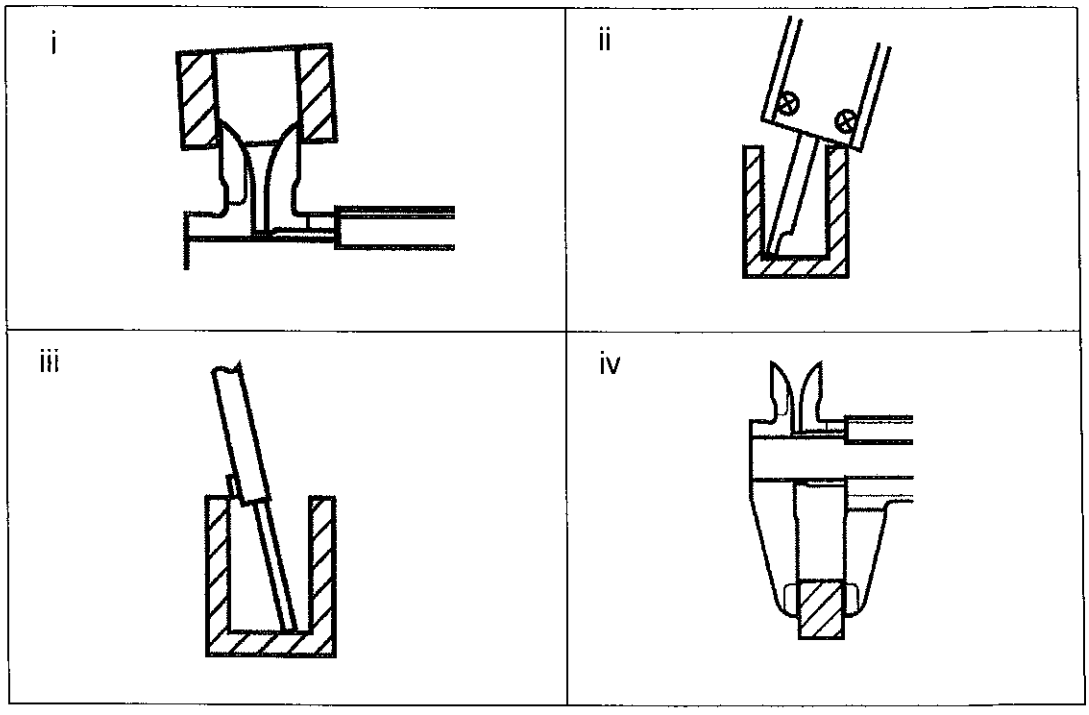


Figure 1: The positions of Vernier caliper while taking a measurement.

(d) Determine the measurement reading by using Vernier Caliper with measuring resolution of 0.02 mm as illustrated in Figure 2. Express your answer in millimeters (mm) and meters (m).

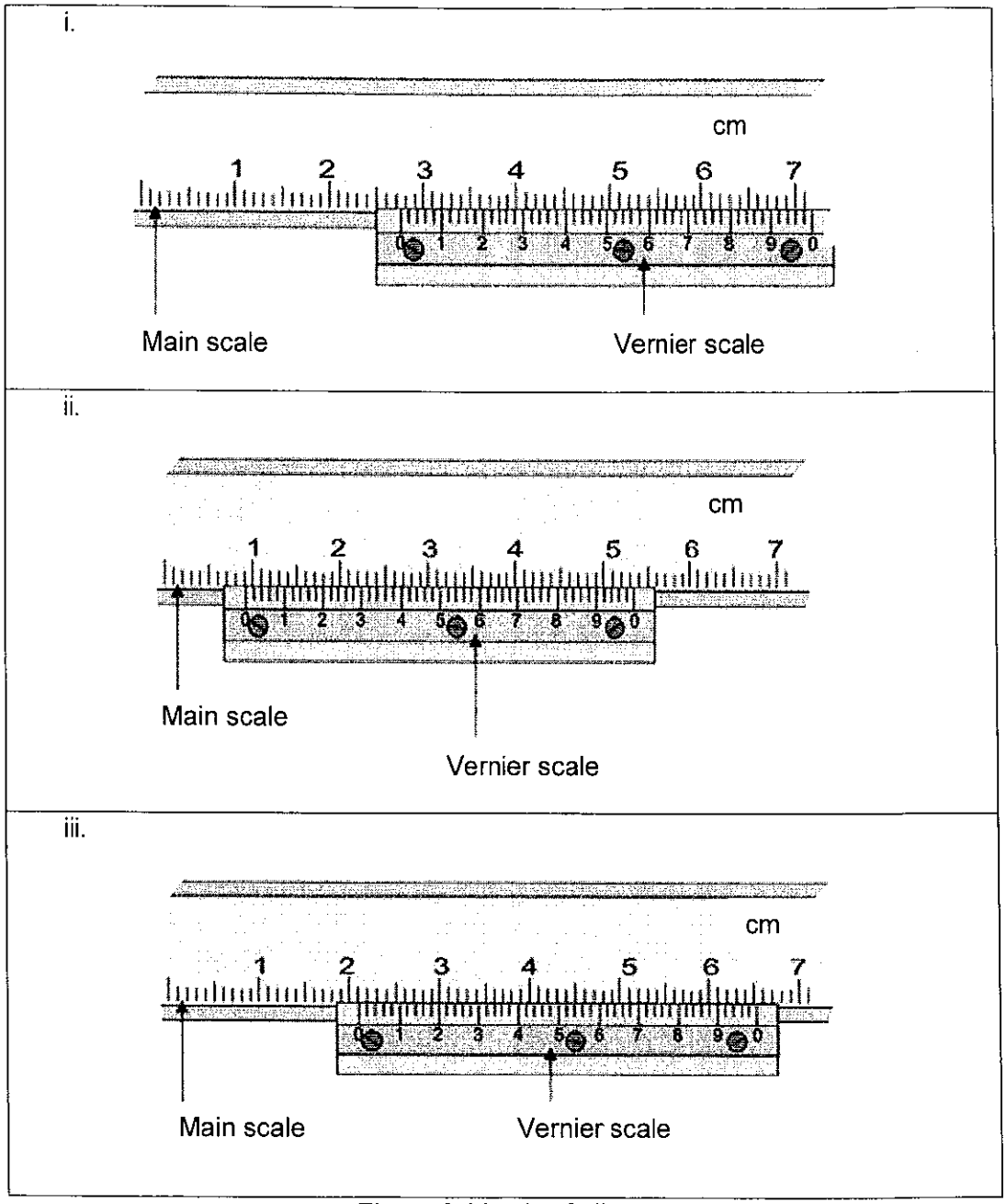


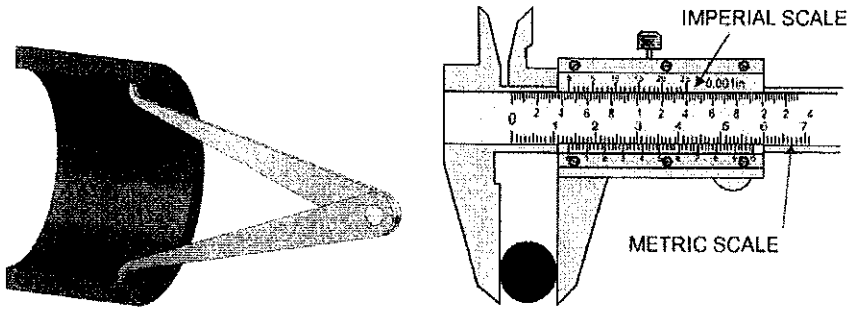
Figure 2: Vernier Caliper.

(6 marks)

Question 2

(a) Accuracy and precision are two important factors to consider when taking data measurements. Describe the terms accuracy and precision and give **ONE (1)** example for each of the term.

(5 marks)



(i) (ii)

Figure 3: (i) Indirect measurement, (ii) direct measurement.

(b) Figure 3 (i) and (ii) above shows two type of measurement method. There are indirect method and direct method. Differentiate between both of the method and explain which methods is more accurate.

(8 marks)

(c) Four students named Harraz, Naufal, Nurin and Farhan make measurements in meters (m) of the length of a beam using a meter stick. Each student's measurements are tabulated in the table below along with the average and standard error of the measurements.

Table 1. Measurements of four students.

	Harraz	**Naufal**	**Nurin**	**Farhan**
Measurement 1	7.83	9.53	8.70	9.72
Measurement 2	11.61	9.38	8.75	9.86
Measurement 3	8.85	8.87	8.77	9.70
Mean	9.43	9.26	8.74	9.76
Standard Error	1	0.2	0.02	0.05

The actual length of the beam is determined by very sophisticated laser measurement techniques to be 9.80 m. By referring to the table above,

i. Explain how to determine the accuracy of a measurement.

(2 marks)

ii. Referring question (i) apply your idea to the measurements of the four students above and rank the students from the most accurate measurement to the least accurate.

(4 marks)

iii. Explain the characteristics of data that indicate a systematic error.

(2 marks)

iv. From data of the four students, analyze which data that have possibility of a systematic error. State which student it is and justify your answer.

(2 marks)

v. Analyze which student has the best measurement considering both accuracy and precision. Justify your answer.

(2 marks)

Question 3

(a) Micrometers can be calibrated using a special set of gauge blocks and a set of optical parallels. List down the basic procedures for calibration of outside micrometer.

(6 marks)

(b)

Table 2. Result of calibration of digital height gauge **A**

Nominal Height	Reading result (mm)			
(mm)	1	2	3	Average
0	0	0	0	0
25	24.983	24.981	24.980	24.981
125	124.996	124.996	124.999	124.997
250	250.003	250.001	250.001	250.002
400	400.002	400.001	399.999	400.001

Table 3. Result of calibration of digital height gauge **B**

Nominal Height	Reading result (mm)			
(mm)	1	2	3	Average
0	0	0	0	0
25	25.002	25.000	25.003	25.002
125	125.000	125.004	124.999	125.001
250	249.988	249.992	249.994	249.991
400	399.999	400.000	399.998	399.999

Table 2 and Table 3 are the results of calibration of Digital Height Gauge. These instruments are calibrated using standard gauge block grade 0. The resolution of both instruments are 0.001 mm and from calibration certificate of gauge block, the standard gauge blocks have expanded uncertainty of 0.1 µm.

With added of evaluation of measurement uncertainty analysis for each instruments, make your judgement which digital height gauge has better accuracy.

(19 marks)

Question 4

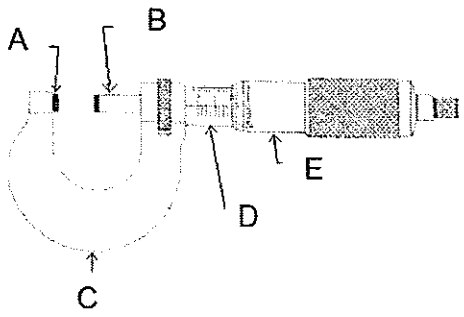


Figure 4: Micrometer parts.

(a) Name the micrometer parts (A, B, C, D, E) as shown in Figure 4.

(5 marks)

(b) There are three types of micrometer. Choose **ONE (1)** type of micrometer and explain its function.

(3 marks)

Table 4. Result of calibration of Dial Gauge Calibrator

Standard Gauge block length (mm)	Reading Result (mm)			Mean	Standard Deviation
	1	2	3		
1.000	0.000	0.000	0.000	0.000	0.000
1.005	0.006	0.005	0.004	0.005	0.001
1.010	0.010	0.009	0.009	0.009	0.001
1.050	0.050	0.050	0.050	0.050	0.000
1.090	0.090	0.090	0.090	0.090	0.000
1.200	0.202	0.201	0.200	0.201	0.001
2.000	1.000	1.000	1.000	1.000	0.000
3.000	2.001	2.001	2.000	2.001	0.001
5.000	4.000	4.000	4.000	4.000	0.000
9.500	8.503	8.501	8.500	8.501	0.002
13.000	12.002	12.002	12.001	12.002	0.001
15.000	14.003	14.002	14.002	14.002	0.001
17.000	16.001	16.002	16.002	16.002	0.001
19.000	18.002	18.003	18.002	18.002	0.001
20.000	19.002	19.002	19.003	19.002	0.001
50.000	49.003	49.005	49.006	49.005	0.002

Table 5. Uncertainty budget.

Source of uncertainty	Type	Uncertainty Value	Probability distribution	Divisor	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
Combined Standard Uncertainty:						
Expanded Uncertainty:						

(c) Table 4 shows a results of Digital Gauge Calibration. This instrument is calibrated using standard gauge block grade 0 with resolution of 0.001 mm. Calibration certificate of gauge block shows the standard gauge blocks has expanded uncertainty of 0.08 µm. The starting temperature is 19.8°C and final temperature is 20.0°C and humidity during calibration is 55%. Based on data in Table 4, evaluate the measurement uncertainty of this digital micrometer by referring to the Table 5.

(17 marks)

Question 5

(a) Describe the following terms;

i. Repeatability.

ii. Reproducibility.

iii. Traceability

iv. Uncertainty

(8 marks)

(b) A QC engineer from Automotive Parts Company had sent out micrometer to National Metrology Laboratory for calibration. After a week, he received back the micrometer with calibration certificate as shown in Figure 5. Interpret the calibration certificate.

(17 marks)

NATIONAL METROLOGY LABORATORY

CALIBRATION REPORT

Instrument : Floating Carriage Diameter Measuring Machine
Serial No. / Manufacturer : [redacted]
Page : 2 of 2
Report No. : [redacted]
Issue Date : [redacted]

Result :

i) Micrometer reading :

Nominal value (mm)	Deviation (mm)
0	0.0000
2.5	-0.0001
5.1	-0.0002
7.7	-0.0000
10.3	-0.0002
12.9	-0.0003
15.0	-0.0001
17.6	0.0000
20.2	-0.0002
22.8	-0.0003
25.0	-0.0003

Expanded Uncertainty of Measurement, U: 0.0003 mm

Remark : Reading (at 20°C) = Nominal value + Deviation

Measurement Standard Used.

Description	Manufacturer	Serial No	Traceability
Gauge Block	Mitutoyo	[redacted]	NML - SIRIM

Calibrated by : [redacted]
Signature : [redacted]

Certified by : [redacted]
Signature : [redacted]

Figure 5: Calibration certificate of Floating Carriage Micrometer.

END OF EXAMINATION PAPER