Safety Hazards
Material Processing Laboratory Room 232

HAZARD: Rotating Equipment / Machine Tools

Be aware of pinch points and possible entanglement

Personal Protective Equipment: Safety Goggles; Standing Shields, Sturdy Shoes
No: Loose clothing; Neck Ties/Scarves; Jewelry (remove); Long Hair (tie back)

HAZARD: Projectiles / Ejected Parts

Articles in motion may dislodge and become airborne.

Personal Protective Equipment: Safety Goggles; Standing Shields

HAZARD: Heating - Burn

Be aware of hot surfaces

Personal Protective Equipment: Safety Goggles**;** High Temperature Gloves; Welding Apron, Welding Jacket, Boot Gauntlets, Face Shield

HAZARD: Chemical - Burn / Fume

Use Adequate Ventilation and/or Rated Fume Hood. Make note of Safety Shower and Eyewash Station Locations.

Personal Protective Equipment: Safety Goggles; Chemically Rated Gloves; Chemically Rated Apron

HAZARD: Electrical - Burn / Shock

Care with electrical connections, particularly with grounding and not Using frayed electrical cords, can reduce hazard. Use GFCI receptacles near water.

HAZARD: High Pressure Air-Fluid / Gas Cylinders / Vacuum

Inspect before using any pressure / vacuum equipment.
Gas cylinders must be secured at all times.

Personal Protective Equipment: Safety Goggles; Standing Shields

HAZARD: Water / Slip Hazard

Clean any spills immediately.

EXPERIMENT # 4

MEASUREMENT INSTRUMENTS AND SYSTEM OF FITS

Goal: To learn the main principles of the System of Fits.

Objectives: To familiarize students with measuring techniques and the use of standard measuring instruments, to practice measuring sample parts, to solve all given problems, to impress upon the students that the degree of accuracy and precision depends upon the skill and ability of the inspector or machinist as well as upon the instrument.

Equipment & Tools: Vernier Caliper, Vernier Height Gauge, Micrometer, Depth Gauge, Telescoping Gauge, Gauge Blocks, Dial Indicator, Comparator, Visual Comparator, Sine Bar, Bevel Protractor, Thread Pitch Gauge, Feeler Gauge, Granite Surface Plate.

Specimens: Various samples of machine parts: shafts, bolts, blocks, parts with inside and outside taper, cylinders, pipes, gears, bushings, pins, screws, and plugs.

Tables of Fits: Clearance, force, transition tables of fits.

Each group of students has to complete all problems given by the Instructor, sketch them and put all necessary dimensions, if necessary make all computations and give the answers to the Set of Questions. Group leader is responsible for distributing the responsibilities among students and producing the Data Sheet.

A report has to be prepared according to the requirements of the General Instruction.

LABORATORY ASSIGNMENT

Your aim for this assignment is to learn how to take actual readings in English and Metric Systems and to use all precision measuring tools listed above.

To assure more complete understanding of how to take readings from measuring tools, be sure that each group of students must complete following assignments:

1. Learn the measuring techniques of different precision instruments (vernier caliper, vernier height gauge, depth gauge, micrometer, and thread pitch gauge).
2. Learn the System of Fits, which can provide a basis for parts dimensioning in the interchangeable manufacturing.

In carrying out your measurement, follow the sequence as given:

1. Perform the measurement on a set of parts using different instruments;
2. Check the accuracy of some instruments;
3. Measure inside taper of the hole in block #20, Fig. 4-1;
4. Measure outside taper of plug, Fig. 4-2;
5. Calculate the diametral pitch of two suggested gears;
6. Check the pitch of the threads of several given screws, Fig. 4-3;
7. Measure the slope of block #7, Fig. 4-4;
8. Supply all measurements with sketches made on the suggested Data Sheet;
9. Measure the outside diameter of the suggested part using vernier caliper, micrometer and vernier height gauge;
10. Read with accuracy to thousandths on the vernier caliper, micrometer and micrometer depth gauges scales shown in Fig. 4- 5 a, b, d;
11. Read with accuracy to ten thousandths on the micrometer scale shown in Fig. 4-5 c;
12. Give the definition of two terms: “allowance” and “tolerance”;
13. Name the eight Classes of Fits which have been established by the American National Standards Institute;
14. Explain the difference between “clearance” and “interference”;
15. Answer the Set of Questions.

HINTS TO THE LABORATORY ASSIGNMENT:

1. **Performance of Measurement.** Your aim for this assignment is to learn how to take actual readings in English and Metric Systems and to use all precision measuring tools listed on page 4-1. To assure a more complete understanding of how each one of the precision measuring tools are to be used, be sure to study supplementary information in your text book [1].

2. **Accuracy of Instruments.** The tools should be checked for accuracy. To check a one-inch micrometer, advance the spindle to anvil. If the zero line of the thimble lines up with the horizontal index line of the barrel, the micrometer is in adjustment. If the zero line fails to coincide with the barrel index line, the tool is out of adjustment.
To check a micrometer or other tools for accuracy, a gauge block of known unit size is inserted between the spindle and the anvil. With the block in place, the tools are accurate if the reading is the same as the known size of the gauge block.

The micrometer and the gauge block must be free of dirt and grit

3. **Measurement of Inside Taper**. To measure the inside taper of the block #20 the two balls of known diameters are used by putting them inside the hole. (See Fig. 4-1). Sketch this situation, draw “ball-slope” contact point and show all steps of slope calculation.

4. **Measurement of Outside Taper**. To measure outside taper of the pipe or plug the vernier caliper must be used.

5. **Diametral Pitch Calculation**. Optical comparator and vernier caliper must be used for calculation of the pitch of the two mating gears. See additional information in [1].

$$D_0 = N+2/P,$$

Use this equation for pressure angle $\alpha=14.5^0$.
Where: D_0 -outside diameter of gear;
N -number of teeth;
P- diametral pitch.

6. **Pitch of the Threads.** Take five different screws and determine the type and size of the threads. Use the screw-thread pitch gauge.

7. **Slope Measurement.** Take block #7 or "Sine Bar". Use the Sine Bar on the master flat surface plate with dial indicator. Setup of the required experiment is shown on Fig. 4-4.

8. **Sketches.** Sketches have to be done on the Data Sheet in accordance with requirements described in the General Instruction.

9. **Measurement of the Part by Different Types of Tools.** For this portion of the experiment use cylindrical parts suggested by your instructor, and three types of precision tools: vernier caliper, micrometer and vernier height gauge. Compare the results of your measurements, give mean value and show the error of your measurements.

10-11. **The Readings of Some Suggested Problems.** To learn how each of three precision measuring tools are read, it is wise to learn first the correct value of each scale of the instrument. After learning each value you should concentrate on learning what is used to determine the readings of each scale. The final or total reading of the instrument in each case can be obtained only by finding the total sum of all scale readings (pointed by arrows) by addition. If you follow these three steps in the given order, you will have no problem with the readings of any precision instrument. Copy Fig. 4-5 with suggested scales, fill in the total reading of the scale and put this page in your report.

12-14. **System of Fits.** For better understanding use the Laboratory Model simulating two mating parts (Shaft and Bushing). You must read suggested references [1,2].

DATA SHEET FOR EXPERIMENT # 4

	GROUP MEMBERS				Weeks:	Week 1	Week 2
	Week 1	Week 2					
1							
2							
3							
4			GROUP:	Group Leader:	Instructor's Approval		
5							
6							
7					DATE:		
8							

SKETCHES:

Inside Tape	Outside Tape
Gear Pitch	**Bolts or Screws**

Continuation of DATA SHEET FOR EXPERIMENT # 4

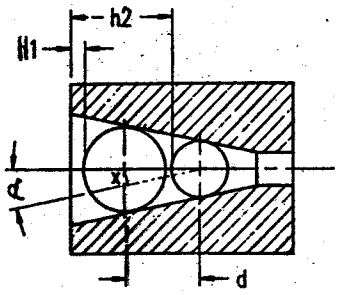
LTR	DATE	REVISION	INITIATED	ECN NO.

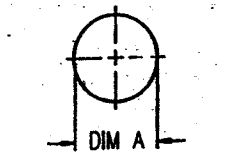
NOTES:

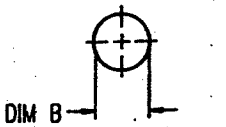
$D = (h_2 + B/2) - (H_1 + A/2)$

$X = A/2 - B/2$

$\alpha = \text{ARC SIN}\ (X/d)$







H1	h2	DIM 'A'	DIM 'B'	RADIUS A (RA)	RADIUS B (RB)	d	ANGLE α°
.117	.918	.750	.500	.500	.500	.801	8.978°

DRAWN	J MILOS
DATE	11-8-96
INSTRUCTOR	R DUBROVSKY
COURSE No.	ME-215A
LAB. No.	4
CAD FILE	FIGS4
SCALE	FULL
MATERIAL	
FINAL FINISH	
HARDNESS	
PLOT DATE	11-22-96

NEW JERSEY INSTITUTE OF TECHNOLOGY

TITLE: INSIDE TAPER MEASUREMENT
LAB 4

DIMENSIONS: IN/MM
TOLERANCES UNLESS OTHERWISE SPECIFIED ARE :
2 PLACE DECIMAL ±.015/0.38
3 PLACE DECIMAL ±.005/0.13
ANGULAR ±2°
FILLETS _____ R
EDGES _____ R OR CHAMFER
BLEND ALL RADII & REMOVE ALL BURRS/FLASH UNLESS OTHERWISE SPECIFIED.

DWG.NO. FIGURE 4 – 1

REV.

LTR	DATE	REVISION	INITIATED	ECN NO.

NOTES: UNLESS OTHERWISE SPECIFIED:
1 APPLICABLE SPECIFICATIONS:
2 FORM. SPECIFICATIONS:

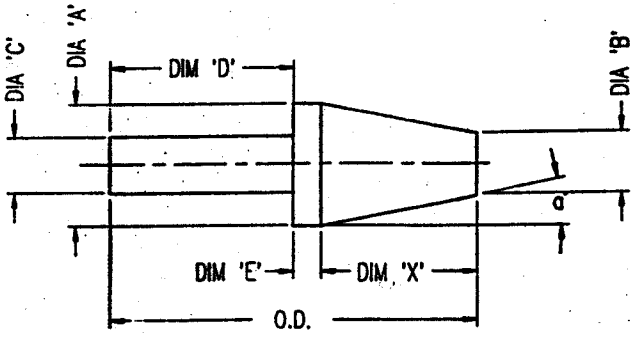
$y = (y1 - y2)/2$

y1 = DIA 'A'
y2 = DIA 'B'

DIM 'X' = O.D. – (DIM 'D' + DIM 'E')

$\alpha = \text{ARCTAN}(y/x)$

X = LENGTH OF TAPER



DIA 'A'	DIA 'B'	DIA 'C'	DIM 'X'	O.D.	DIM 'D'	DIM 'E'	ANGLE 'α'
1.0625"	.5375"	.4875"	1.400	3.3125"	3.3125"	.250	10.62°

DRAWN	J MILOS
DATE	11-9-96
INSTRUCTOR	R. DUBROVSKY
COURSE No.	ME-215A
LAB. No.	4
CAD FILE	FIGS4
SCALE	FULL
MATERIAL	
FINAL FINISH	
HARDNESS	
PLOT DATE	11-11-96

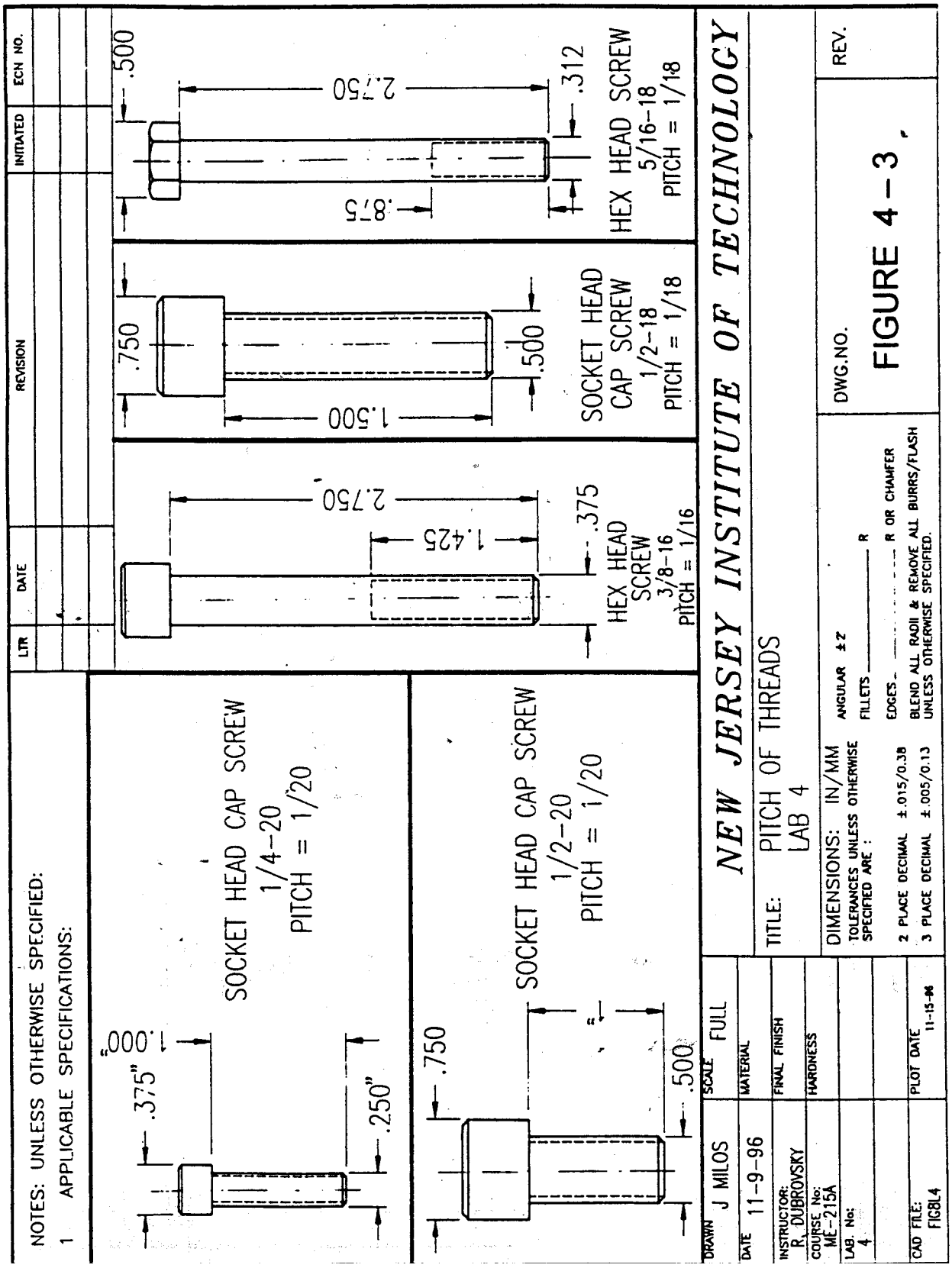
NEW JERSEY INSTITUTE OF TECHNOLOGY

TITLE: MEASUREMENT OF OUTSIDE TAPER
LAB 4

DIMENSIONS: IN/MM
TOLERANCES UNLESS OTHERWISE SPECIFIED ARE :
2 PLACE DECIMAL ±.015/0.38
3 PLACE DECIMAL ±.005/0.13
ANGULAR ±2°
FILLETS _____ R
EDGES _____ R OR CHAMFER
BLEND ALL RADII & REMOVE ALL BURRS/FLASH UNLESS OTHERWISE SPECIFIED.

DWG.NO. FIGURE 4 – 2

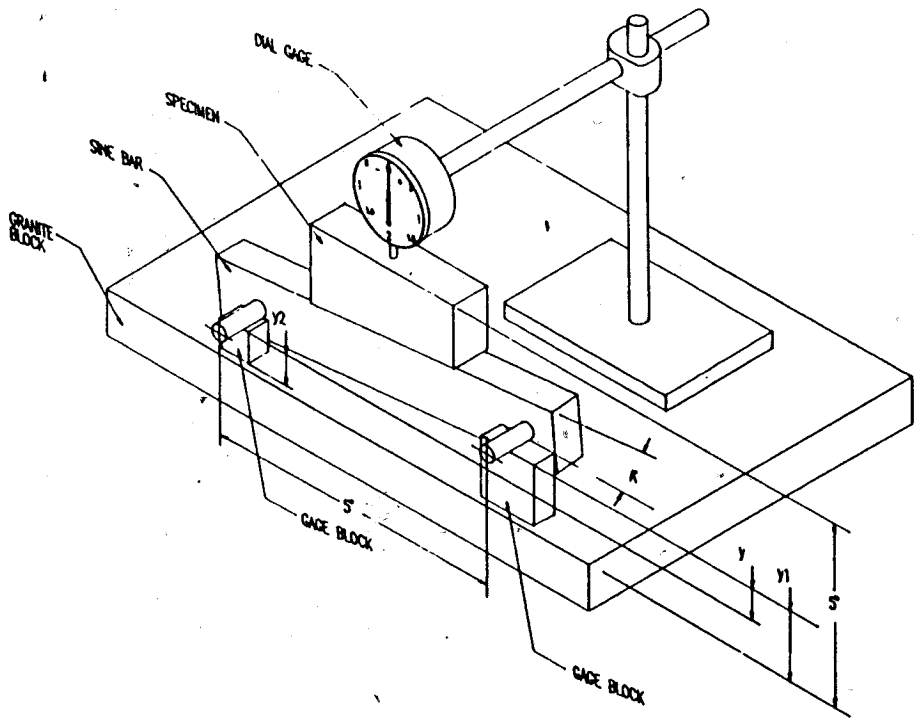
REV.

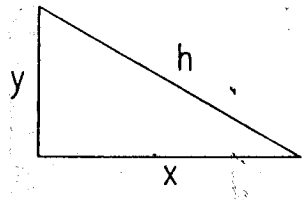

NOTES: UNLESS OTHERWISE SPECIFIED:
1 APPLICABLE SPECIFICATIONS:
LTR
DATE
REVISION
INITIATED
ECN NO.
1.000"
.375"
.250"
SOCKET HEAD CAP SCREW
1/4-20
PITCH = 1/20
.750
.500
SOCKET HEAD CAP SCREW
1/2-20
PITCH = 1/20
2.750
1.425
.375
HEX HEAD SCREW
3/8-16
PITCH = 1/16
.750
1.500
.500
SOCKET HEAD CAP SCREW
1/2-18
PITCH = 1/18
.500
2.750
.875
.312
HEX HEAD SCREW
5/16-18
PITCH = 1/18
DRAWN J MILOS
SCALE FULL
DATE 11-9-96
MATERIAL
INSTRUCTOR: R. DUBROVSKY
FINAL FINISH
COURSE No: ME-215A
HARDNESS
LAB. No: 4
CAD FILE: FIG8L4
PLOT DATE 11-15-96
NEW JERSEY INSTITUTE OF TECHNOLOGY
TITLE: PITCH OF THREADS
LAB 4
DIMENSIONS: IN/MM
TOLERANCES UNLESS OTHERWISE SPECIFIED ARE :
2 PLACE DECIMAL ±.015/0.38
3 PLACE DECIMAL ±.005/0.13
ANGULAR ±2°
FILLETS _____ R
EDGES _____ R OR CHAMFER
BLEND ALL RADII & REMOVE ALL BURRS/FLASH UNLESS OTHERWISE SPECIFIED.
DWG.NO.
REV.
FIGURE 4 – 3

NOTES: UNLESS OTHERWISE SPECIFIED:

1 APPLICABLE SPECIFICATIONS:

LTR	DATE	REVISION	INITIATED	ECN NO.





DRAWN: J MILOS	SCALE: N/A
DATE: 11-7-96	MATERIAL:
INSTRUCTOR: R. DUBROVSKY	FINAL FINISH:
COURSE No: ME-215A	HARDNESS:
LAB. No: LAB 4	
CAD FILE: FIG6L4	PLOT DATE: 11-8-96

NEW JERSEY INSTITUTE OF TECHNOLOGY

TITLE: SLOPE MEASUREMENT SETUP
LABORTORY No 4

DIMENSIONS: IN/MM
TOLERANCES UNLESS OTHERWISE SPECIFIED ARE :

2 PLACE DECIMAL ±.015/0.38
3 PLACE DECIMAL ±.005/0.13

ANGULAR ±2°
FILLETS _____ R
EDGES _____ R OR CHAMFER
BLEND ALL RADII & REMOVE ALL BURRS/FLASH UNLESS OTHERWISE SPECIFIED.

DWG.NO.

FIGURE 4 – 4

REV.

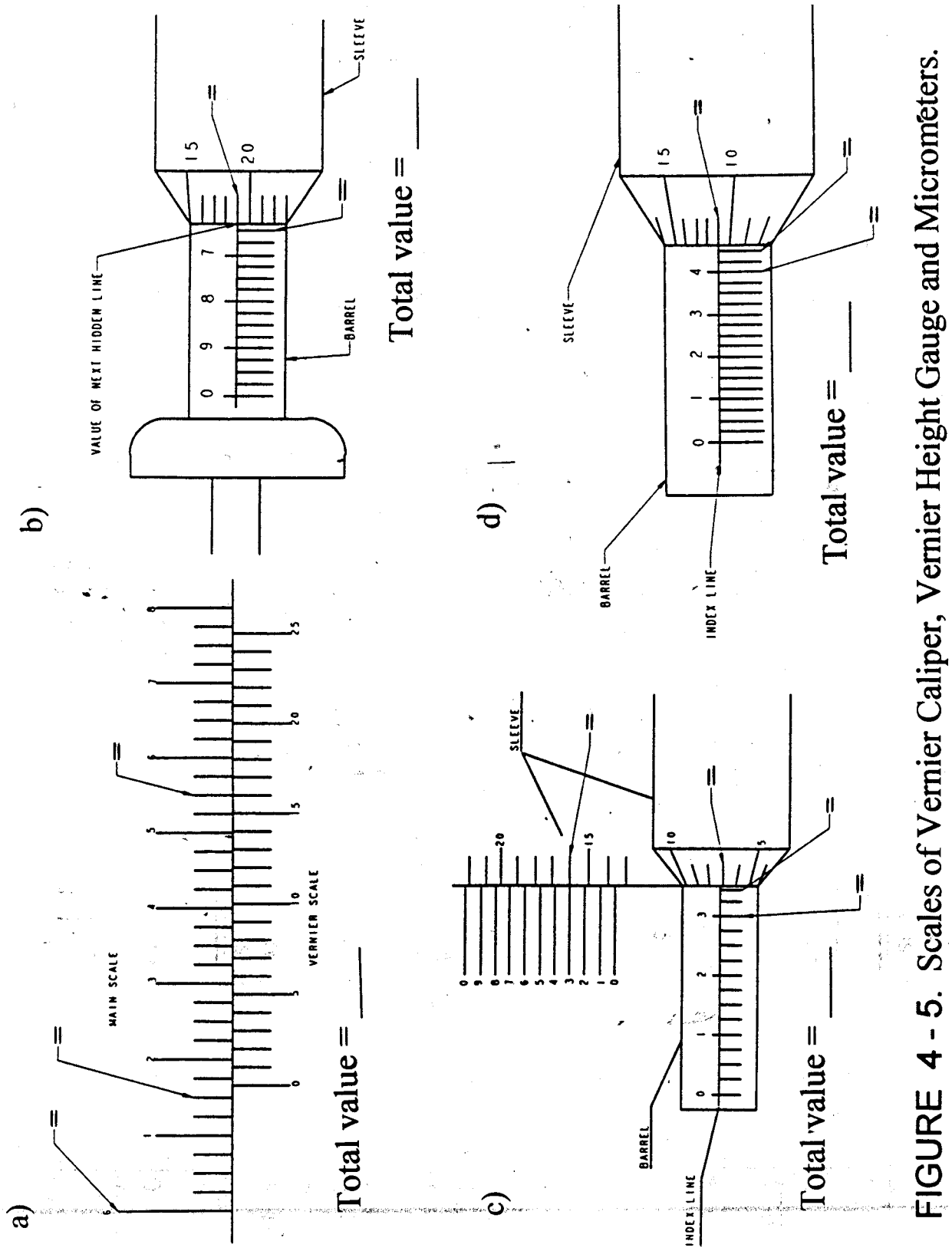


FIGURE 4 - 5. Scales of Vernier Caliper, Vernier Height Gauge and Micrometers.

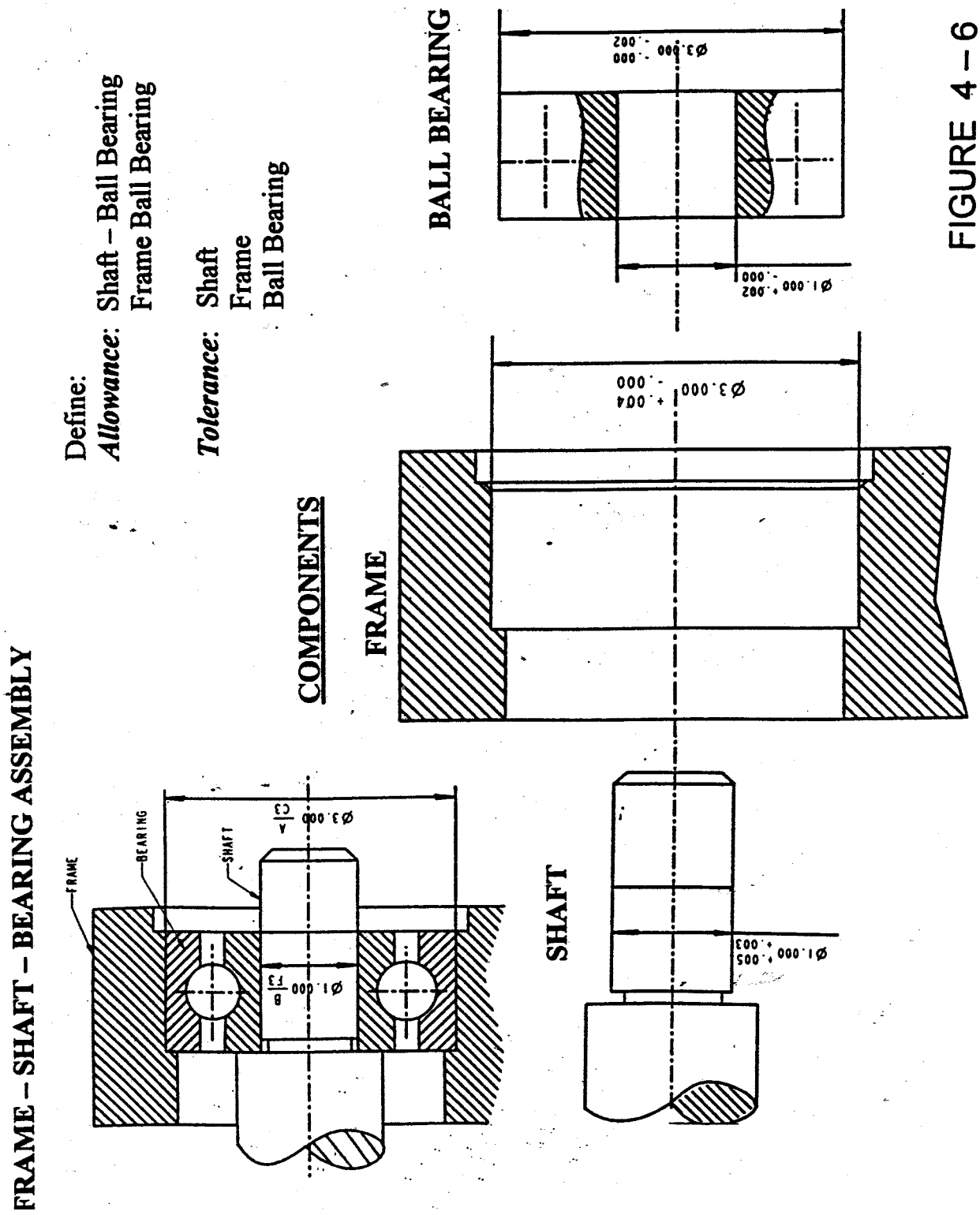

FRAME – SHAFT – BEARING ASSEMBLY
Define:
Allowance: Shaft – Ball Bearing
Frame Ball Bearing
Tolerance: Shaft
Frame
Ball Bearing
COMPONENTS
FRAME
BALL BEARING
SHAFT
FRAME
BEARING
SHAFT

FIGURE 4 – 6

SET OF QUESTIONS

1. What is the designation of the scriber of the vernier height gauge?
2. What is meant by the term “tolerance”?
3. What two ways can be used to check the accuracy of micrometer?
4. Discuss the advantage of the International System of Fits over English System of Fit.
5. Give the total readings of instruments shown in Fig. 4-5 a, b, c, d.
6. Calculate allowance and tolerance for three mating parts (shafts-ball bearing- frame assembly) shown in Fig.4-6.
7. Describe the Basic Hole System in order to assign the required tolerances during our design.
8. A shaft and hole have a nominal diameter of 1 in. The shaft has a tolerance of 0.003in, the hole has a tolerance of 0.004in and the allowance is set at 0.001in. The dimensions are based on the Basic Hole System. Show the deviations for the shaft and the hole from nominal size; calculate the maximum and minimum clearance for two mating parts.

SUGGESTED LITERATURE

1. E. Pual De Garmo, J.T.Black, R.A.Kohler. Materials and Processes in Manufacturing, 8th Edition, Macmillan, NY, 1997

2. A.D.Deutschman, Walter J. Michels, C. E. Wilson. Machine Design. Macmillan Publishing Co., Inc. NY, 1985.

3. ANSI Standard B4. 1-1067, “Preferred Limits and Fits to Cylindrical Parts”.

4. ASTM, Handbook of Industrial Metrology, Prentice-Hall, Inc., Englewood Cliffs, N. J. 1967.

5. R.Dubrovsky. Laboratory Manual, Engineering Materials & Processes, ME Department, NJIT, CAPCO, Oklahoma, 1998.