

Tomsk Polytechnic University

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TECHNOLOGY of MECHANICAL ENGINEERING

Part 1

Workbook

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This workbook is devoted to fixing of accuracy in mechanical engineering and bases of the theory of cutting action.

This workbook is prepared at the TPU Department of Mechanical Engineering.

It is recommended for foreign students following the Bachelor Degree Program in Mechanical Engineering at the Tomsk Polytechnic University.

Reviewed by: V.F. Skvorsov, the head of the department “Technology of Mechanical Engineering, Cutting and Tools”

TO THE STUDENT

The discipline "Technology of mechanical engineering" is studied on the senior rate for the bachelor level in 7 and 8 semesters and is divided into two parts. The parts "Fixing of accuracy in mechanical engineering and bases of the theory of cutting action" are studied in the seventh semester (3 credits). The part second "Technological opportunities of machine tools and designing of technological processes" is studied in the eighth semester (3 credits). At the end of each semester the examination by the appropriate parts is stipulated.

This workbook is written in according with the textbook "Technology of Mechanical Engineering", part 1. The material in the Workbook is presented in the same order and with the same section division as in the textbook. The Workbook contains exercises which must fulfill. This workbook covers the topics to be studied in 5 terms:

1. Measurements and measuring tools.
2. Inspection of surface form, disposition of surfaces and surface finish.
3. Tolerances and fits.
4. Cutting tools.
5. Bases of the cutting action.

1. Measurements and Measuring Tools

1. For what purposes are the following measuring tools used? Describe the main principles of action:

1) Rules

2) Caliper rules

3) Rule depth gages

4) Combination depth and angle gages

5) Squares

6) Combination sets

7) Protractor heads

8) Center heads

9) Die maker's squares

10) Cylindrical squares

11) Calipers

12) Center gages

13) Radius gages

14) Machinist's vises

15) Scribes

16) Dividers

17) Prick punches

18) Center punches

19) Surface plates

20) Straightedges

21) V-blocks

22) Telescoping gages

23) Small-hole gages

24) Adjustable parallels

2. Enumerate principal parts of micrometer.

3. Enumerate the principal characteristics of a micrometer.

4. The readings on the micrometer are of 12.45 mm and 12.95 mm. Explain it.

5. For what purposes are the outside, inside and depth micrometers used? Describe the main principle of action.

6. For what purposes are the vernier calipers used? Enumerate its principal kinds.

7. Show vernier reading of 121.35 mm. Explain it.

8. For what purposes is the universal bevel protractor used? Show reading of $12^{\circ}45'$. Explain it.

9. For what purposes are the dial indicating instruments used? Enumerate its principal kinds.

10. How to check and set the indicating hole gage?

11. For what purposes are the gage blocks used? Describe the procedure for building the gage block combinations (for example, 125.673 mm).

12. For what are the purposes limits gages used? Enumerate its principal kinds.

13. For what purposes are the toolmaker's microscopes and optical comparators used?

14. For what purposes is the sine bar used? How to establish the angle of 25° ?

2. Inspection of Surface Form, Disposition of Surfaces and Surface Finish

1. Complete the following sentences:

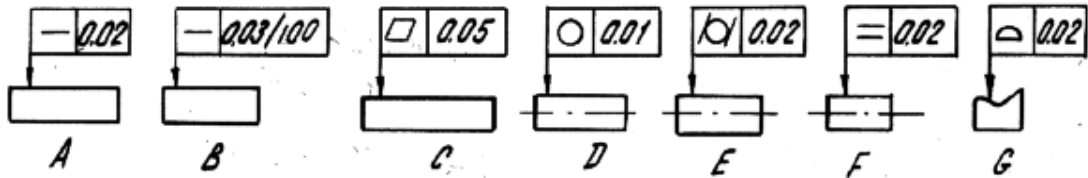
1.1. Deviation from the straight is

1.2. Deviation from the flatness is

1.3. The levels of relative geometrical accuracy are established depending on

1.3. Deviation from the roundness is

2. Explain the following symbols:



A

B

C

D

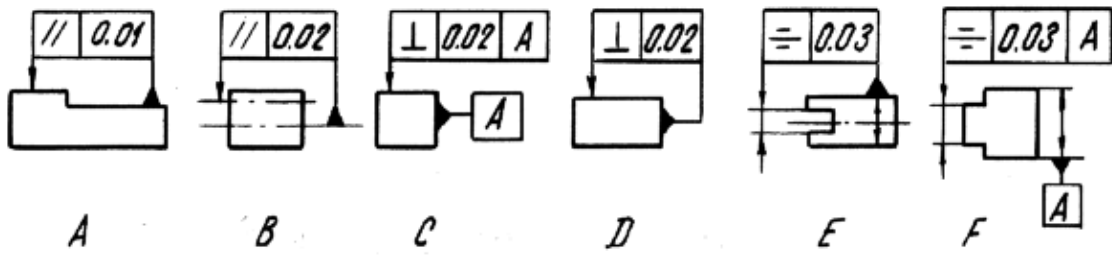
E

F

G

3. Deviation of the disposition of a surface or a profile is

4. Explain the following symbols:



A _____

B _____

C _____

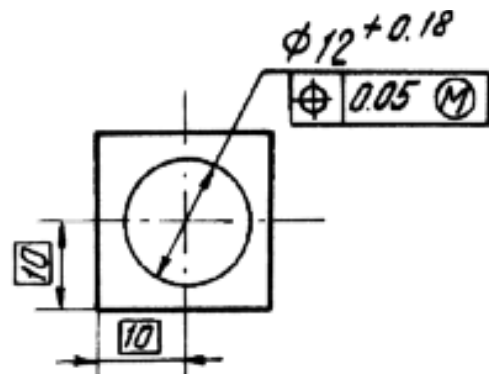
D _____

E _____

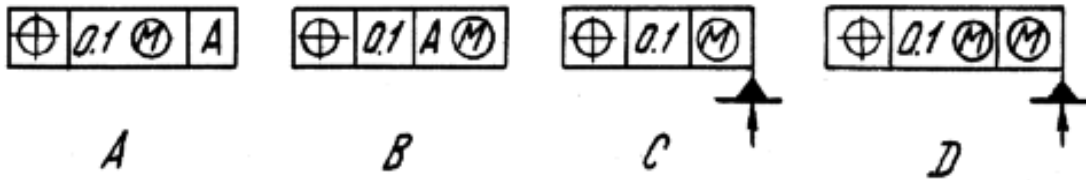
F _____

5. The dependent tolerance is

6. Explain the following symbol:



7. Explain the following symbols:



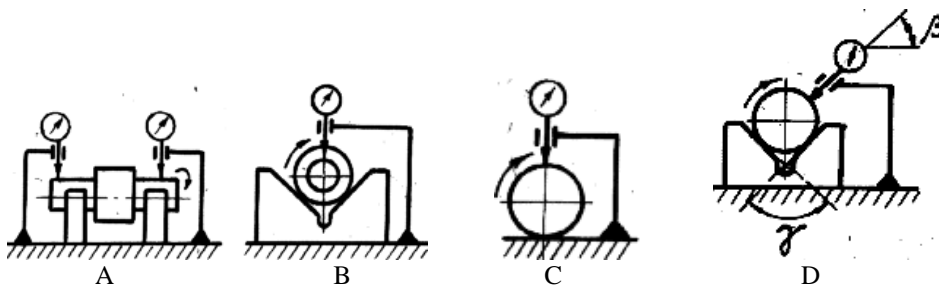
A _____

B _____

C _____

D _____

8. Explain the following schemes of the deviation measurements:



A _____

B

C

D

9. Complete the following sentences:

1) The roughness average is

Ra =

2) The roughness sampling length ℓ is

3) The standard values of the roughness sampling length ℓ are (mm):

4) The height of the profile roughness by ten points is

Rz =

5) The roughness spacing on the centerline is

$S_m =$

10. How to measure the flatness of a surface using an optical flat?

3. Tolerances and Fits

1. How to measure a part ($d=75.1$ mm) by the method of relative measurements?

2. Complete the following sentences:

1) The actual size is

2) The basic size is

3) The fundamental deviation is

4) The tolerance is

3. Define deviations of the tolerance zones:

- 1) 60g6
- 2) 60g7
- 3) 60G6
- 4) 60G7
- 5) 60h6
- 6) 60H6
- 7) 60s7

4. Define the minimum and maximum clearances for the fit 20H7/g6

5. Define the limiting interferences for the fit 80H7/s7

6. Define the limiting interference and clearance for the fit 50H7/n6

7. Define the limiting interference and clearance for the rolling bearing fits 30B0/n6 and 70H7/b0

8. Define the deviations of shaft group tolerance zones for the fit with $S_{\max} < [S_{\max}] = 18 \mu\text{m}$ and $S_{\min} > [S_{\min}] = 2 \mu\text{m}$ for the basic size 20 mm when we can produce parts with tolerance $T = 16 \mu\text{m}$. Use the method of selective assembly.

Answer: 1-st gr. $20^{-0.002}_{-0.01}$ mm
2-nd gr. $20^{+0.006}_{-0.002}$ mm

9. Define the deviations of limit gages to check the shaft and the hole of the fit 30H7/g6.

Answer: 30H7 NOT-GO $\rightarrow 30.023_{-0.004}$ mm
30H7GO $\rightarrow 30.005_{-0.004}$ mm
30H7GO_{wear} $\rightarrow 30.005_{-0.007}$ mm
30g6 NOT-GO $\rightarrow 29.978^{+0.004}$ mm
30g6 GO $\rightarrow 29.988^{+0.004}$ mm
30g6 GO_{wear} $\rightarrow 29.988^{+0.007}$ mm

10. Define the deviations of tolerance zones for the slot free junction with the basic size 6 mm.

Answer: Shaft slot $\rightarrow 6H9^{(+0.03)}$ mm
Hole slot $\rightarrow 6D10_{(+0.03)}^{+0.078}$ mm
Key $\rightarrow 6h9_{(-0.03)}$ mm

11. Write a lubrication of the slit junction for centring on an external diameter if the slit junction has 8 slit, external diameter 50 mm, the internal diameter is 46 mm, the slit width is 7 mm. (for example: d-8 x 36H7/e8 x 40H12/a11 x 7D9/f8.)

Answer: D-8 x 46H12/a11 x 50H7/e8 x 7D9/f8.

12. Write the work size of corner 20° for grade tolerance 17.

Answer: $20^\circ \pm 1^\circ$.

13. Complete the following sentences:

1) The major diameter of a screw thread is

2) The minor diameter is

3) The pitch diameter is

4) The pitch is

5) The lead is

6) The angle of a thread is

7) The lead angle is

8) The depth of engagement is

9) The length of engagement is

14. Define limit diameters of a screw and a nut for the thread junction M16 x 2–7H/6g.

Answer: $D_{\min} = 16 \text{ mm}$

$$d = 16^{-0.038}_{-0.318} \text{ mm}$$

$$D_2 = 14.701^{+0.265} \text{ mm}$$

$$d_2 = 14.701^{-0.038}_{-0.163} \text{ mm}$$

$$D_1 = 13.835^{+0.475} \text{ mm}$$

$$d_{1\max} = 13.707 \text{ mm}$$

15. Where is the square thread used?

16. Why the square thread cannot be made efficiently with dies, taps or milling cutters?

17. Where is the acme thread used?

18. Why can the acme thread be made efficiently with dies, taps or milling cutters?

19. Why are the Brown and sharpe worm threads used in worm gear drive systems?

20. Why must a pipe compound be used to seal the clearance space which exists between the crests and roots of the mating threads?

21. Where are the straight pipe threads (NPS) sometimes used?

22. Where are the American standard Dryseal pipe threads (NPTF) used?

23. How are the processes of cutting internal and external threads called?

24. What kind of measuring tools can be used for measuring and checking threads?

25. What is the peculiarity of all the methods of the pitch diameter measurement?

26. What profile has a not-go gage and why?

27. What profile has a go gage and why?

28. What types of gears do you know?

29. What is the module of gear?

30. What is the circular pitch?

31. How to calculate the module?

32. What is the base circle?

32. What is the pitch circle?

33. What is the pitch line?

34. What is the line of action?

35. What is the pressure angle?

36. What are the basic forms (or curves) used for gear teeth?

37. Why are the SI metric 20° and the American Standard 20° gears not interchangeable?

38. What norms of accuracy do you know?

39. What is the kinematics error of a gear?

40. What parameters of the kinematics accuracy of gears do you know?

41. What parameters of the smoothness of work of gears do you know?

42. What parameters of the transfer teeth contact do you know?

43. What kinds of interfaces determining various values $j_{n \min}$ are established?

44. What kinds of the tolerances T_{jn} are established for a lateral clearance?

45. How to define the lateral clearance $j_{n \min}$ for compensating the temperature deformations?

46. What does 7-6-7-Ca/V -128 mean?

47. What is necessary to mark on the assembly drawings?

48. What is necessary to mark on the design drawings?

49. What is the histogram?

50. What kind of curves for probability density functions y of random variable x do you know?

51. What formula is used to calculate an average square-law mistake?

52. What is the dispersion of measurements?

53. What is the factor of variance?

54. What is a confidence level?

55. What is a confidence interval?

56. What are the typical mean-square errors used in practical measurements?
Explain why.

57. What is the Student factor?

58. What characteristics are needed to describe the random errors?

59. What does the confidence level α depend on in the table of the Student factor?

60. We have received the values 50.1; 50.3; 50.4; 50.3; 49.9 mm (five measurements of a hole diameter). It is required to define the confidence level where the average arithmetic differs from true value no more than on 0.08 mm.

63. Can the least squares method recommend the kind of approximating function?

64. Why a diagram is presented sometimes in double logarithmic coordinates?

65. A meter stick (read to the nearest mm) is used to measure a length of 120 mm. What is the absolute uncertainty? What is the relative uncertainty?

Answer: ± 5 mm; 0,4%.

66. A travelling microscope can be read to 0.1 mm. What is the precision of the measurement of a distance of 10 mm?

Answer: 0,5%.

67. What is the smallest distance which can be measured using a meter stick (read to mm) so that the uncertainty shall not exceed (a) 1 per cent, (b) 5 per cent?

Answer: 50 mm; 10 mm.

68. A distance of 20 mm must be measured to 1 per cent. (a) Would a meter stick be suitable? (b) Would a travelling microscope (read to 0.1 mm) be suitable?

Answer: a) No; b) Yes.

69. A barometer reading normal atmospheric pressure can be read to 0.1 mm. What is the precision?

Answer: 0,007%.

70. An ammeter reading 0-5 amp is graduated in 0.1 amp. Assuming that it is read to the nearest scale division, what is the precision of measurement (a) at full scale? (b) at 1 amp?

Answer: a) 1%; b) 5%.

71. It is stated that today is 5.4° warmer than yesterday. Both measurements were made on the same thermometer read to 0.2° . What is the precision of this statement?

Answer: 3,7%.

72. A density measurement gives the following figures: mass, $24.32 \text{ g} \pm 0.005$; volume, $10.2 \pm 0.05 \text{ cc}$. What is the absolute uncertainty in the density?

Answer: 0.012 g cc^{-1} .

73. Repeated measurements of the diameter of a wire of circular cross section gave the mean of 0.41 mm with the sample standard deviation of 0.07. What is the sample standard deviation of the resulting calculation of the cross-sectional area?

Answer: 0.045.

74. The coefficient of linear expansion α of a solid is to be measured using the equation

$$l = l_0(1 + \alpha \cdot \Delta T).$$

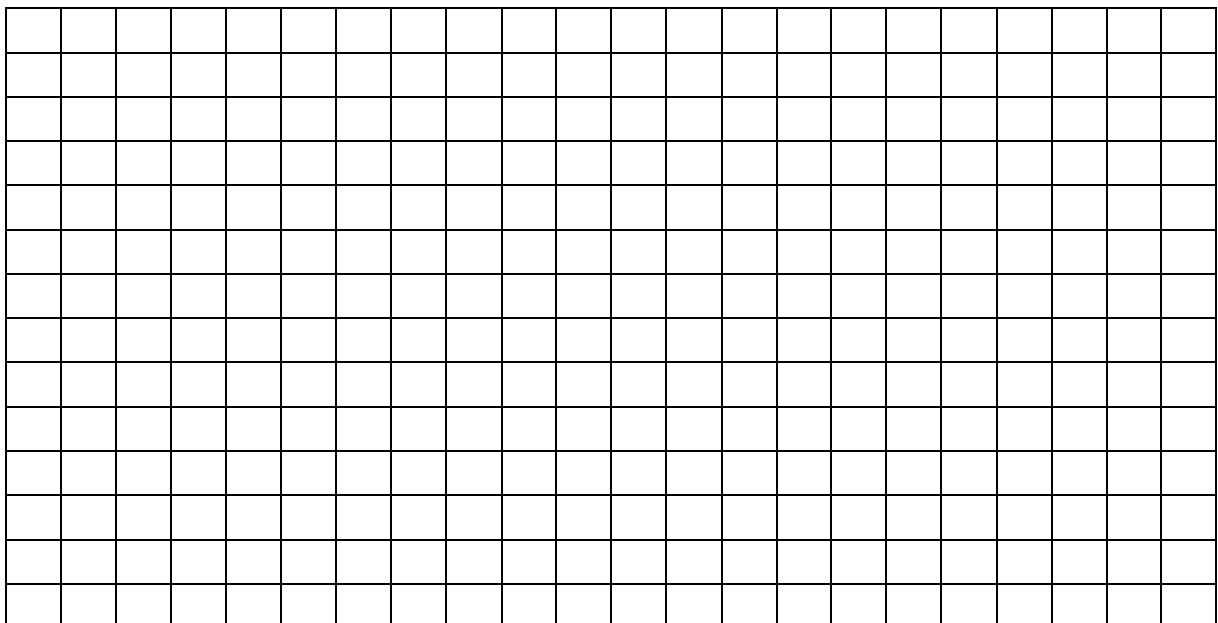
The length l_0 is about 500 mm and the expansion $l - l_0$ can be measured to 0.05 mm. Knowing that α is about 2×10^{-5} and neglecting the uncertainties in measuring l_0 and ΔT , calculate the minimum temperature range ΔT which will permit α to be measured to 10 %.

Answer: approximately 50° .

75. The following observations of angles (in minutes of arc) were made while measuring the thickness of a liquid helium film. Assume that the observations show random uncertainty and that they are a sample from a Gaussian universe.

34	35	45	40	46
38	47	36	38	34
33	36	43	43	37
38	32	38	40	33
38	40	48	39	32
36	40	40	36	34

Draw the histogram of the observations.



76. Identify the mode and the median for this histogram.

Answer: between 38 and 39; 38.

77. Calculate the mean.

Answer: 38.30.

78. Calculate the best estimate of the universe standard deviation.

Answer: 4.388.

79. Calculate the standard deviation in the mean.

Answer: 0.801.

80. Calculate the standard deviation of the standard deviation.

Answer: 0.576.

81. Within which limits does a single reading have (a) a 68 % chance of falling, and (b) which limits give a 95 % chance?

Answer: a) ± 4.388 about the universe mean.
b) ± 8.776 about the universe mean.

82. Within which limits does the mean have (a) a 68 % chance, and (b) a 95 % chance of falling?

Answer: a) ± 0.801 about the universe mean.
b) ± 1.602 about the universe mean.

3. Cutting Tools

1. What principles are the edged cutting tools based on to cut metals?

2. How can the cutting tools be classified? (3 kinds of classification.)

3. What types of the single-point tools do you know?

4. Why are the inserted tools (indexable throwaway inserts) widely used?

5. What types of the tool bits do you know?

6. What are the differences between the various types of metal-cutting tools?

7. What elements and surfaces of the cutting tools do you know? (Enumerate 9 elements and surfaces.) Describe them.

12. The end-relief angle is

13. What are the working angles?

14. The grinding angle is

15. What is the side cutting edge angle?

16. What is the end cutting edge angle?

17. Why should only the required amount of end or side relief be used?

18. What are the end- and side-relief angles fairly standard for turning many common metals with high-speed steel tools?

19. What are the end- and side-relief angles used for turning many common metals with tungsten-carbide tools?

20. The back-rake angle is

21. What is the positive rake angle?

22. The side rake angle is

23. The main front angle is

24. The angle of keenness is

25. The main angle in the plan is

26. For what purpose are the chip breakers used?

27. What types of chip breakers do you know?

33. What are the coated high-speed steel tools?

34. What cutting tools are made of a high-speed steel?

35. What are the cast alloys?

36. Where are the cast alloys used?

37. What are the advantages and disadvantages of the cast alloys in comparison with the high-speed steels?

45. What precautions should be executed when using the of cemented-carbide cutting tools?

46. What are the cermet cutting tools?

47. What are the ceramic cutting tools?

48. What are the advantages and disadvantages of the ceramic and cermet in comparison with the cemented-carbides?

49. What are the advantages and disadvantages of diamonds in comparison with the cemented-carbides?

50. What are the general rules which should be followed as a guide in selecting cutting speeds for cutting tools made of different materials?

5. Bases of the Cutting Action

1. What is the depth of cut?

2. What is the cutting speed?

3. What is the cutting feed?

13. How does the built-up end influence the roughness of a processed surface?

14. How to calculate a cutting speed?

15. How to calculate the cutting force?

16. Where does the wear of cutting tool take place on the cutting edge?

21. What are the principal purposes of a cutting fluid at high speeds?

22. What are the components used for straight cutting oils?

23. Enumerate the useful properties of straight cutting oils.

24. What does the term “transparent oils” mean?

25. What are the advantages and disadvantages of the two basic types of mineral cutting oils?

26. What are the emulsifiable oils?

27. What are the advantages and disadvantages of the emulsifiable oils?

28. What can other types of cutting fluids and means beside the straight cutting oils, the emulsifiable oils, and the chemical or synthetic cutting fluids be used in machining metals?

29. Enumerate the principal factors which can be used as a guide in selecting a cutting fluid for a particular application?

30. How many classified groups of metals are there according to their approximate machinability ratings?

31. What do you know about the commonly used lathe tool bits and their applications?

32. What does the amount of relief angle depend on?

33. What are the average tool angles for single-point high-speed steel tools used for cutting medium-carbon steel?

34. What are the average tool angles for single-point high-speed steel tools used for cutting cast iron (hard)?

35. What are the average tool angles for single-point high-speed steel tools used for cutting aluminum?

36. What are the recommended angles for single-point carbide tools used for cutting aluminum?

37. What are the recommended angles for single-point carbide tools used for cutting carbide steels SAE 1025?

38. What are the recommended angles for single-point carbide tools used for cutting stainless steel, hardenable?

39. What are the recommended angles for single-point carbide tools used for cutting high-nickel alloys?

40. What are the recommended angles for single-point carbide tools used for cutting titanium alloys?

49. What cutting speeds are used for cutting the medium-carbon steels with H.S.S. cutting tool?

50. What cutting speeds are used for cutting the medium-carbon steels with a carbide cutting tool?

51. What cutting speeds are used for cast iron cutting with a carbide cutting tool?

52. What is the main cause of cutting tool wear?

53. What is the tool life usually used?

54. Why are the cutting fluids used in grinding operations?

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