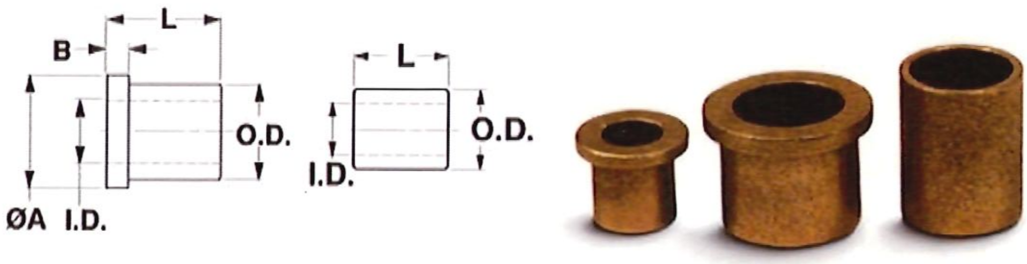
ME 481/581 Midterm Exam – Spring 2026

- **Open Books/Notes/Computers - Allotted time 100 minutes**
- **Please do not draw or write solutions on exam papers.**
- **Write on only one side of provided copy paper.**
- **Bracket the answers**
- **Solve the problems in order and clearly separate them**

1. The sintered bronze bearing shown in the figure is to be used to support a motor shaft.



Bore Sizes (d)	12 mm
Bore Tolerances	+0.050 / +0.032
Outside Dia.	18 mm
O. D. Tolerances	+0.041 / +0.023

a) [10 points] Determine the shaft size limits for an unconstrained fit to bearing bore. The shaft to bearing bore fit is to have fit identical to a "close running fit".

2. We have bought standard Woodruff keys where the width of the keys is 5h9 in size limits. The design guidelines for Woodruff keys recommends a N9/js9 fit.

a) [10] Determine the keyway size limits such that the recommended fit is achieved with the 5h9 keys.

3. Consider the part in Figure-1

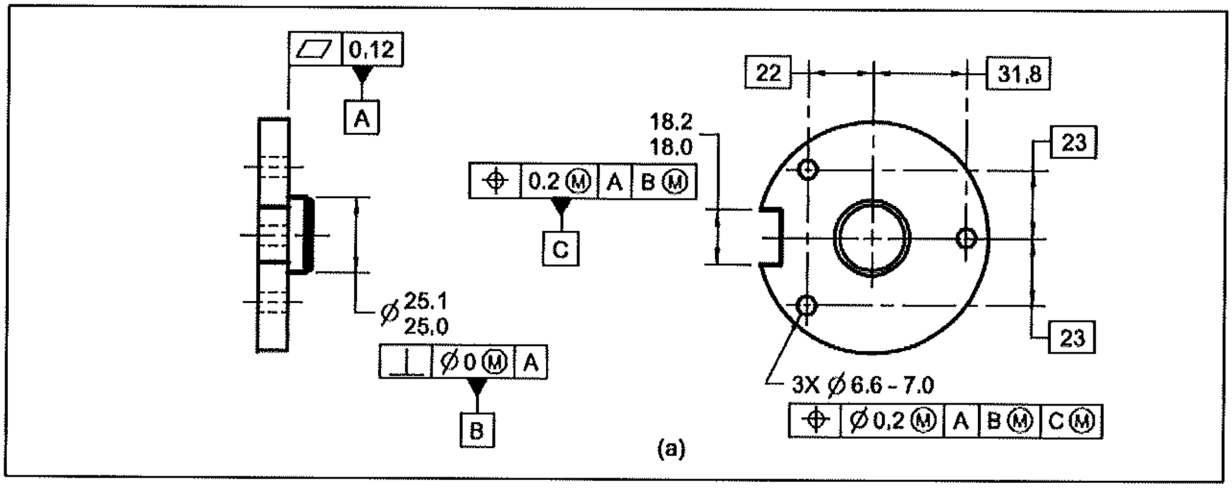


Figure-1

For these following gages, use the plane of the paper as datum-A. Only draw the gage, do not show part profiles.

4. [5] Draw theoretical gage(s) necessary to check the size of the slot (in Figure-1)

5. [5] Draw a theoretical gage for the perpendicularity tolerance (in Figure-1)

6. [5] Draw a physical gage for the perpendicularity tolerance (in Figure-1)

7. [10] In Figure-1, Determine the size limits of the mating hole for the center boss such that P_{min}=0 and P_{max} = 0.3 mm. The mating hole uses zero perpendicularity tolerance at MMC.

The following problems is not related to Figure-1

8. [5] The size limits of a shaft feature are 15.00 – 15.25 that is used with 0.2 mm perpendicularity tolerance at MMC. Convert the size limits to ZGT format.

9. [10] Determine the shaft size limits for an unconstrained fit to a ball bearing bore. The ball bearing bore size is 25 +/- 004 mm. The shaft to bearing bore fit is to have fit limits identical to a 25H7/n6 locational transition fit.

10. [5] Convert 25L6 coded size limits to numerical limits. The letter code (L) is not one of the known standard codes and not in the LAF program – This is just to test if you can do the conversion w/o the use of the program. You can use the program for finding the IT6 tolerance value.

25L6
Fundamental deviation (offset) = -0.05
Lower Deviation

11. [5] Draw theoretical gage for the straightness specification below in Figure-2.

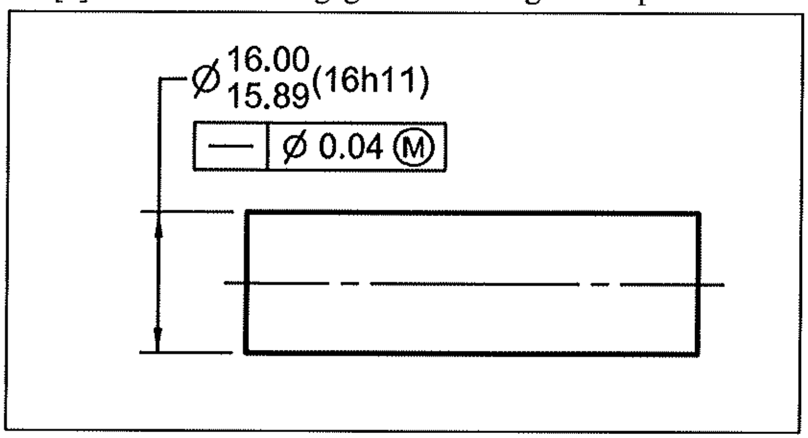


Figure-2

12. [5] Draw theoretical gage for the straightness specification in Figure-2 if it were specified RFS (without the MMC symbol).

13. [5] Draw the theoretical gage for perpendicularity tolerance of the boss feature in Figure-3 in this view.

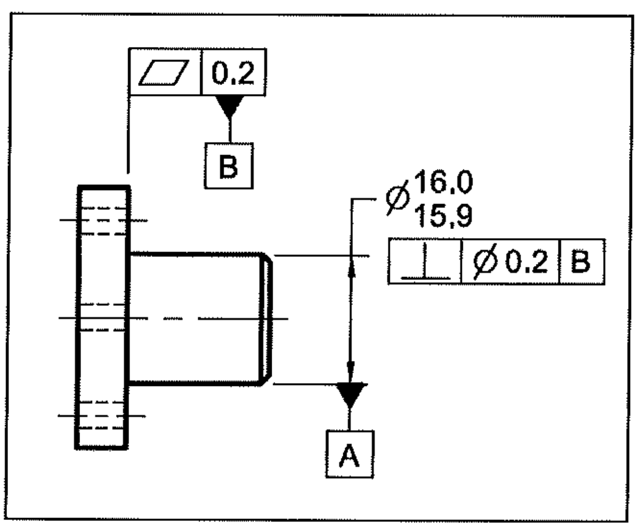


Figure-3

14. [10] The bearing shown in the figure is to be fit to a motor shaft. We have selected the one with a bore size of 15 mm.

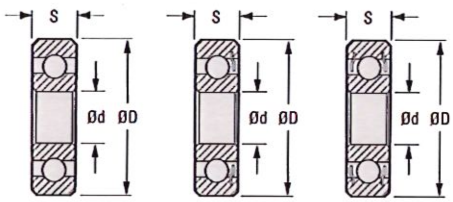


Fig. 1 No Shield | Fig. 2 Single Shield | Fig. 3 Double Shield

METRIC COMPONENT						
Catalog Number			d Bore 0 -0.008	D Outer Ring Dia. 0 -0.01	S Width 0 -0.12	Shaft & Housing Fillet Radius Max.
Fig. 1 No Shield	Fig. 2 Single Shield	Fig. 3 Double Shield				
A 7C55MP1905	A 7C55MPS1905	A 7C55MPSS1905	5	19	6	0.5
A 7C55MP1906	A 7C55MPS1906	A 7C55MPSS1906	6	19	6	0.5
A 7C55MP2207	A 7C55MPS2207	A 7C55MPSS2207	7	22	7	0.5
A 7C55MP2208	A 7C55MPS2208	A 7C55MPSS2208	8	22	7	0.5
A 7C55MP2609	A 7C55MPS2609	A 7C55MPSS2609	9	26	8	0.5
A 7C55MP3010	A 7C55MPS3010	A 7C55MPSS3010	10	30	9	0.6
A 7C55MP3212	A 7C55MPS3212	A 7C55MPSS3212	12	32	10	0.6
A 7C55MP3515	A 7C55MPS3515	A 7C55MPSS3515	15	35	11	0.6
A 7C55MP4017	A 7C55MPS4017	A 7C55MPSS4017	17	40	12	0.6
A 7C55MP4720	A 7C55MPS4720	A 7C55MPSS4720	20	47	14	1
A 7C55MP5225	A 7C55MPS5225	A 7C55MPSS5225	25	52	15	1

a) Determine the shaft size limits for an unconstrained fit to the bearing bore. The shaft to bearing bore fit is to have fit identical to a 15H7/n6 locational transition fit. (note make sure you manually enter H7 for the hole – The LAF shows H6 if you use the drop down menu for locational transition fit)

15. [10] Consider the fit of a hole and a pin in an orientation-constrained fit. The nominal size of the features is 25 mm. Both features must be specified in ZGT (Zero Geometric Tolerance) format. The minimum play is to be zero and the maximum play must not exceed 0.2 mm. For the most economical design, both feature sizes are to border the nominal size of 25 mm.

a) Using equal tolerances for both features, determine the size limits of the two features.

Midterm Exam Solutions

#1) Desired fit 12 H8/f7

$P_{min} = 0.016$

$P_{max} = 0.061$

Also given

$H_{min} = 12.032$

$H_{max} = 12.050$

Solution

$P_{min} = H_{min} - F_{max}$

$0.016 = 12.032 - F_{max} \Rightarrow \boxed{F_{max} = 12.016}$

$P_{max} = H_{max} - F_{min}$

$0.061 = 12.050 - F_{min} \Rightarrow \boxed{F_{min} = 11.989}$

#2) Woodruff Key fit

Given: $F_{min} = 4.97$ $F_{max} = 5.00$ (for 5h9)

Desired fit N9 / JS9

$P_{min} = -0.045$

$P_{max} = +0.015$

Find: Hmin and Hmax (Using $T_H = T_F = 0$)

$P_{min} = H_{min} - F_{max}$

$-0.045 = H_{min} - 5$

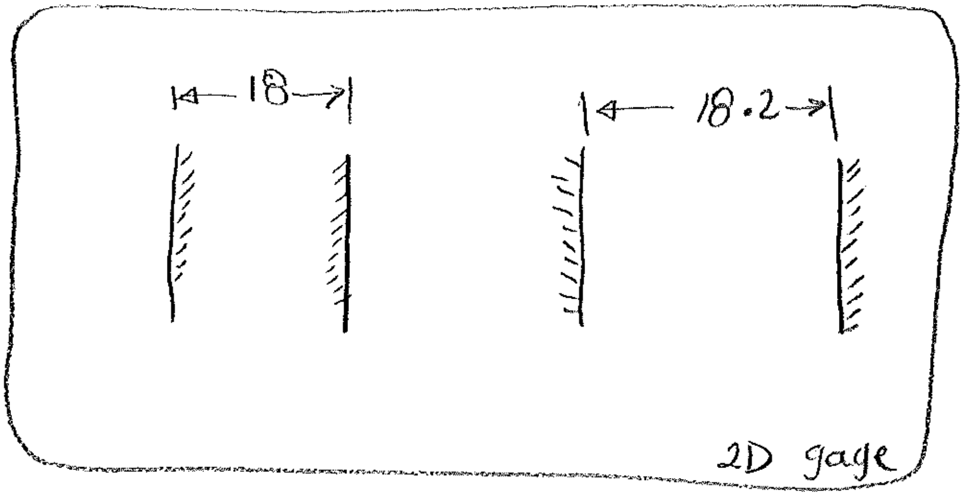
$\Rightarrow$ $\boxed{H_{min} = 4.955}$

$P_{max} = H_{max} - F_{min}$

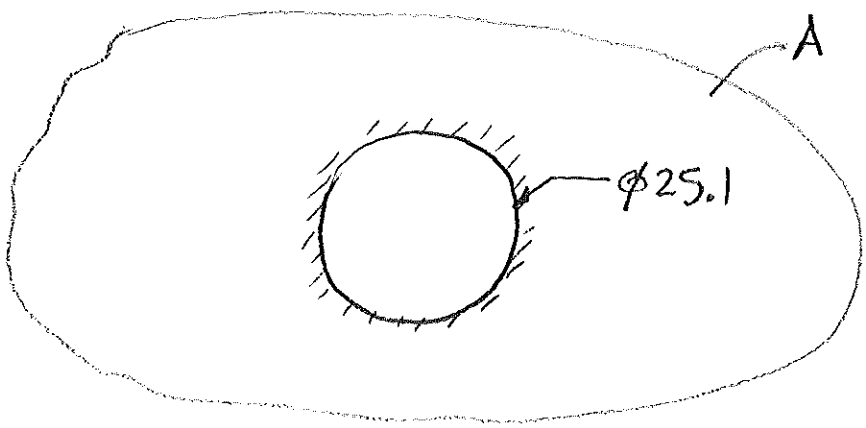
$0.015 = H_{max} - 4.97$

$\Rightarrow$ $\boxed{H_{max} = 4.985}$

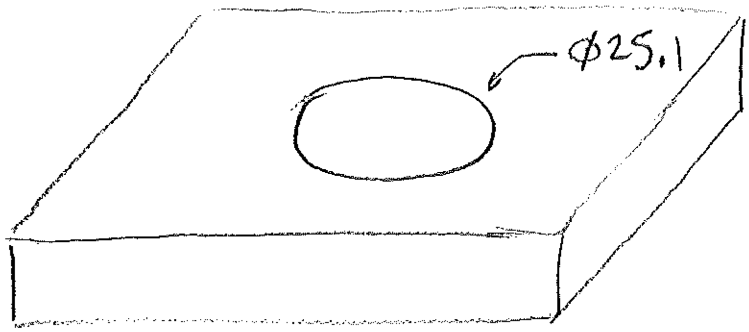
#4)



#5)



#6)



#7) Size limits of mating hole

$P_{min} = H_{min} - F_{max}$ (with $T_F = T_H = 0$)

$0 = H_{min} - 25.1 \Rightarrow \boxed{H_{min} = 25.1}$

$P_{max} = H_{max} - F_{min}$

$0.3 = H_{max} - 25 \Rightarrow \boxed{H_{max} = 25.3}$

#8) Shaft

$\phi 15.00 - 15.25$

⊥	ϕ 0.2 Ⓜ	A

=

$\phi 15.00 - 15.45$

⊥	ϕ 0 Ⓜ	A

#9) Given $H_{min} = 24.996$

$H_{max} = 25.004$

Desired fit 25 H7/n6 $\Rightarrow \begin{cases} P_{min} = -0.028 \\ P_{max} = 0.006 \end{cases}$

Find F_{min}, F_{max}

$P_{min} = -0.028 = H_{min} - F_{max} = 24.996 - F_{max}$

$\Rightarrow \boxed{F_{max} = 25.024}$ $\quad P_{max} = 0.006 = H_{max} - F_{min}$

$\Rightarrow \boxed{F_{min} = 24.998}$

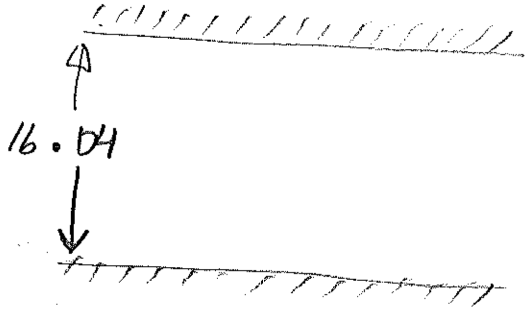
#10) Convert 25L6 (IT6 = 0.013)
FD = −0.05

Lower Deviation

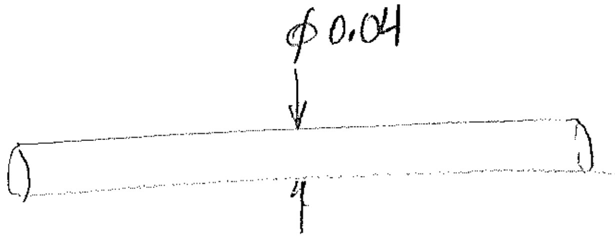
$$H_{min} = 25 + (-0.05) = \boxed{24.950}$$

$$H_{max} = 24.95 + 0.013 = \boxed{24.963}$$

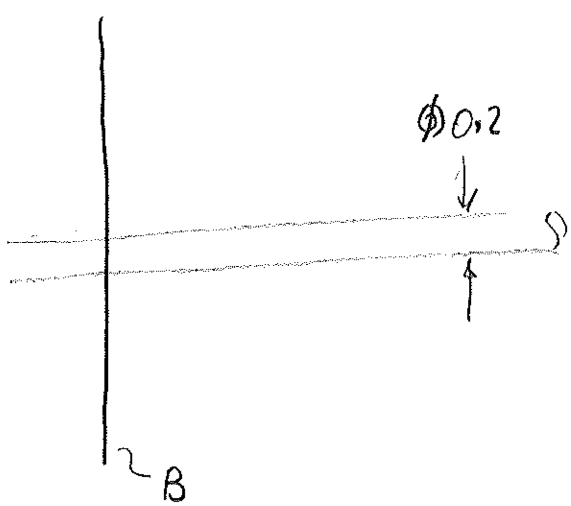
#11)



#12



#13



#14) Bearing bore size limits

$H_{max} = 15$

$H_{min} = 14.992$

Desired fit : 15 H7/m6 $\left(\begin{array}{l} P_{min} = -0.023 \\ P_{max} = 0.006 \end{array} \right)$

Find F_{min} , F_{max}

$$P_{min} = H_{min} - F_{max}$$

$$-0.023 = 14.992 - F_{max}$$

$$\Rightarrow \boxed{F_{max} = 15.015}$$

$$P_{max} = H_{max} - F_{min}$$

$$0.006 = 15 - F_{min} \Rightarrow \boxed{F_{min} = 14.994}$$

#15) The short-hand formula when $P_{min} = 0$ is to divide P_{max} by 2 $\left(\frac{0.2}{2} = 0.1\right)$ and use $\frac{P_{max}}{2}$ for both feature

Shaft	≡ 24.90 – 25.00
Hole	≡ 25.00 – 25.10