Technical University of Munich
TUM Department of Aerospace and Geodesy

Participant number:	
Name, first name:	

Sample Test Machine Elements/CAD Master Aerospace

Please place your ID in front of you.
You have 60 minutes to answer the questions of this test.

This test contains 18 numbered pages including cover sheet.

Please check your test copy for completeness!

Do not use red or green pens or a pencil! Only use a permanent pen.

Allowed aids are pen, non-programmable calculator, a ruler and a compass/circle.

Written answers and drawings must be clean, clear and concise. The corrector is not going to interpret your answers.

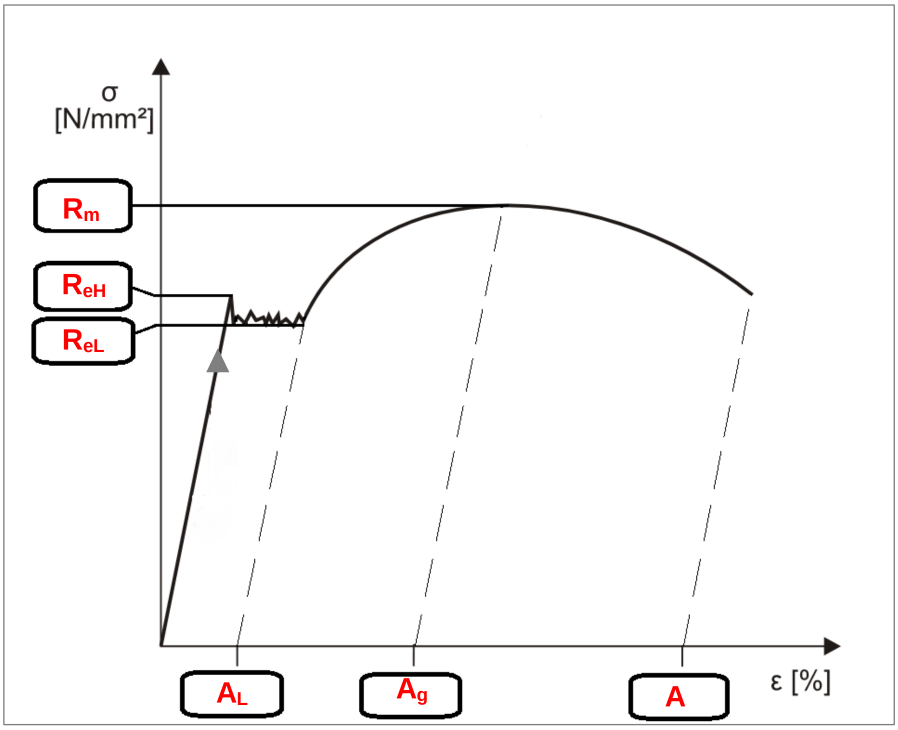
Do not fill in this table.

Exercise	Machine Elements	Machine Drawing (CAD)	**Passed:**
Maximum reachable points			☐ **yes** ☐ **no**
Reached points			

Machine Elements	(/)

Strength – Stress	(/ 8)

The following stress-strain curve of a metallic test piece is given in this task. It has been determined in a static tensile test. The graph shows the engineering stress-strain during the test.



Question 1: Insert the symbols for tensile strengh R_m, upper yield point R_{eH}, lower yield point R_{eL} into the empty boxes of the diagram.

Insert the symbols for Lüders expansion A_L, uniform elongation A_g and breaking elongation A as well.

Question 2: A point on the engineering stress curve is marked with a rectangle (σ=150 N/mm^2, ε=0,0714 %). Calculate Young's Modulus of the material.

E	=	210084 N/mm^2

Question 3: Why does the engineering stress show a maximum though the corresponding strain is significantly lower than the breaking elongation? Explain in 2-3 short and complete sentences.

The maximum of the engineering stress marks the point where the constriction of the test piece is getting significant. The true stress is still increasing (does not show a maximum at this point). Engineering stress is calculated using a constant reference cross-section and does not account for contriction.

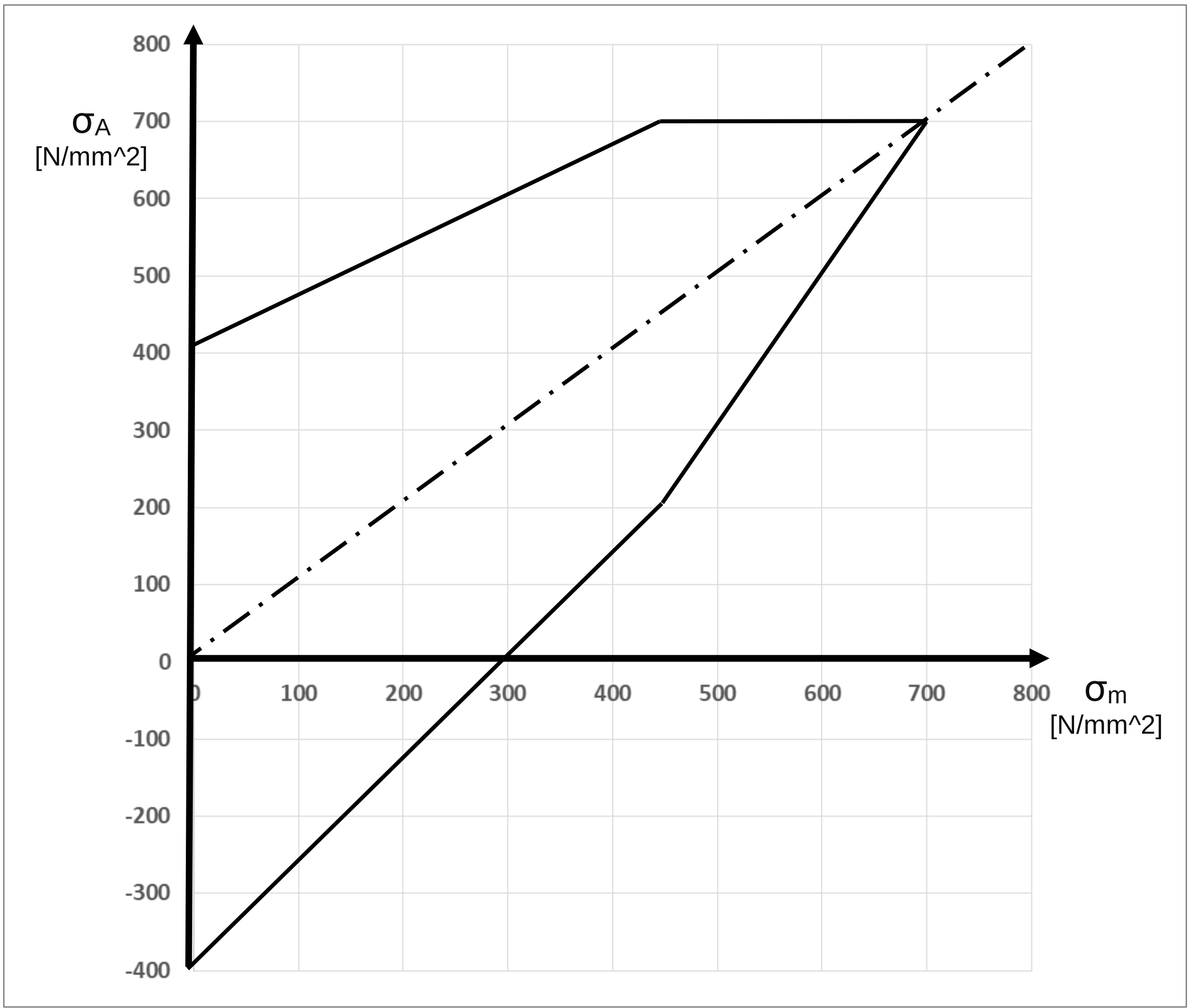
Question 4: Estimate the material of the test piece. Formulate your arguments in 1-3 short and complete sentences.

The shape oft he yield point and the value of Youngs's modulus indicate that the test piece could be of unalloyed steel.

...

Strength – Smith Diagram (/ 4)

Given is the following fatigue-strength diagram (Smith-diagram) of a metallic test piece. It shows deflection tension σ_A over mean tension σ_m for conditions under which fatigue strength can be assumed.



Question 1: Which mean tension $\sigma_{m,t}$ marks the transition from alternating load to swelling load in the diagram?

$\sigma_{m,t}$ = ...300........... N/mm^2

Question 2: Explain the sharp bend in the upper deflection tension curve at σ_m = 450 N/mm^2 in 1-2 short and complete sentences.

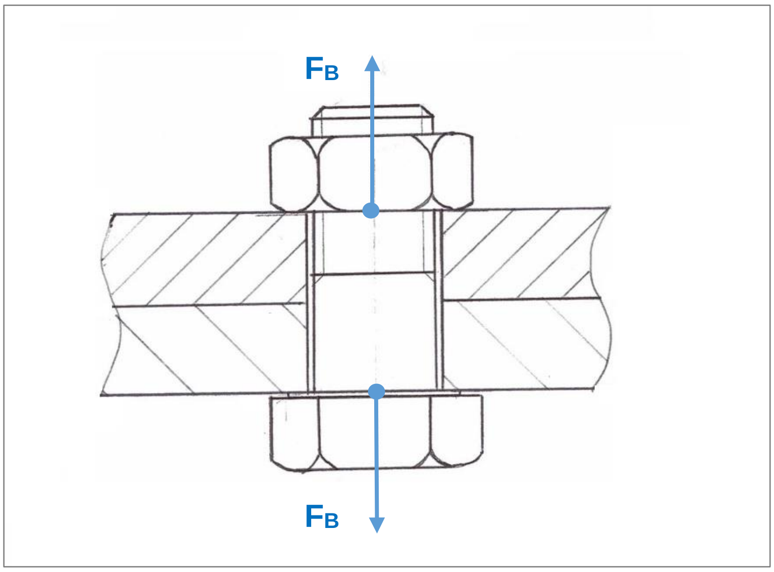
In case upper deflection tension would show values higher than the tensile strength then fatigue strength would not be true anymore. This is why this curve shows a sharp bend when the value of tensile strength is reached.

Question 3: Which is the maximum possible mean tension σ_m if the deflection tension is allowed to reach 200 N/mm^2?

$\sigma_{m,t}$ = **500** .... N/mm^2

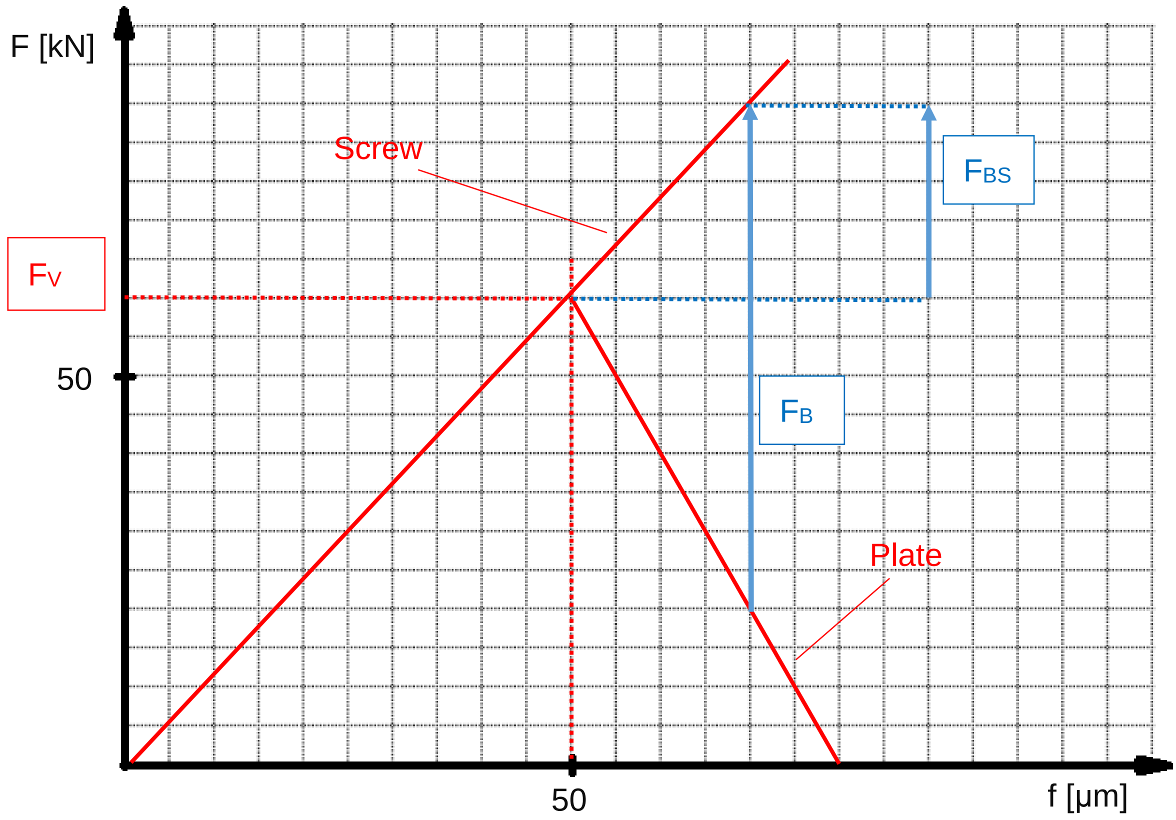
Screw Connection	(/ 5)

Two steel plates are connected by a screw connection (force fit). In production, this connection is done with a preload force F_V. An operating force F_B acts during operation.



Question 1: Sketch the srew connection in the diagram given below. Mark the preload force (which is 60 kN) in your sketch. The stiffness of the screw is 1,2 kN/µm and the stiffness of the plate is 2 kN/µm. (red)

Question 2: Sketch the operating force (which is 65 kN) in the diagram as well. Mark the part of the operating force that loads the screw (F_{BS}). (blue)


F [kN]
Screw
FV
FBS
50
FB
Plate
50
f [µm]

Seals

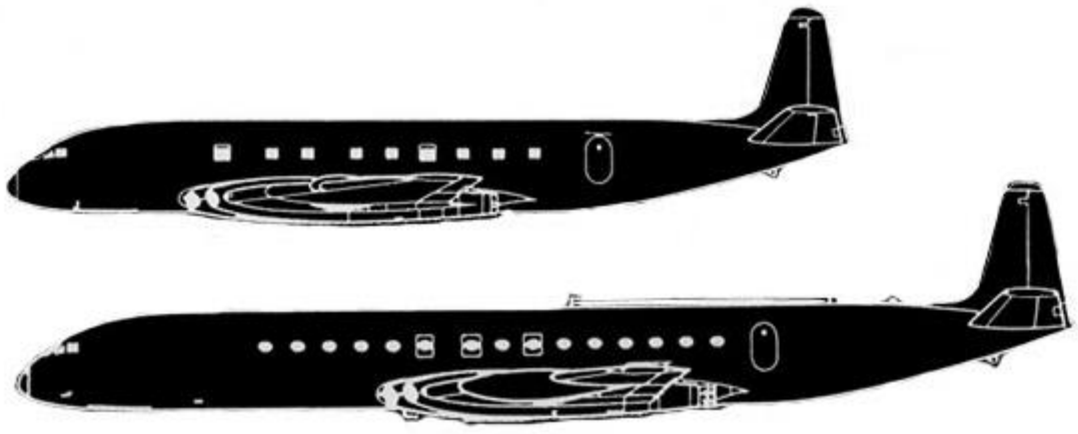
(/ 3)

Which of the following statements are true?

- [ ] When radial shaft sealing rings are used, the running surface on the shaft must have a surface hardness of no more than 40 HRC.
- [x] Felt rings can be used with grease lubrication.
- [x] The sealing effect of O-rings is based on the deformation of their cross section in installed condition. The resulting reaction force gives the required contact pressure force.
- [x] Radial shaft sealing rings must be centered to the sealing surface.
- [ ] Slide seal rings are not suitable for sealing rotating shafts.
- [ ] Labyrinth seals operate with friction and wear, but are completely sealed.

Case Study: de Havilland DH.106 Comet	(/ 7)

The picture below shows the first version (top) and fourth version (bottom) of the de Havilland DH.106 Comet, the aircraft was the first passenger jet aircraft built in series.



After several aircraft of the first version were lost, some in rather mysterious circumstances, an investigation was conducted in 1954. The investigation concluded with a recommendation to change the shape of windows (see picture above). The recommendations were realized in later versions, improving the safety record.

Mind the hint given below and explain:

1. Why was the change in window shape recommended?
2. How did the change in shape improve safety?

(Mind that this aircraft flew considerably higher that propeller aircraft. The stress on the hull due to pressure difference inside and outside the fuselage was considerably larger.)

1. The change in shape was recommeded in order to reduce peak streass in the corners of the windows (1 point).
2. The increased altitudes increased the amplitude of the load-cycle experienced by the fuselage due to steady internal pressure for passengers and decreasing ambient pressure (1 point). The change of window shape helped increase the service life span of the fuselage (1 point).

Mechanical Drawing	(/)

CAD	(/)

Question 1:

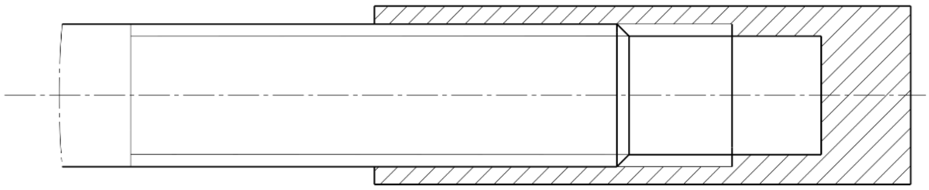
What is the difference between a CAD model created with a 2.5D system and a CAD model created with a 3D system?

The model created with the 2.5D system does not contain volumetric information. (1 Point)

Drafting	(/)

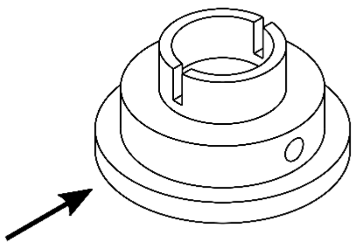
Question 1:

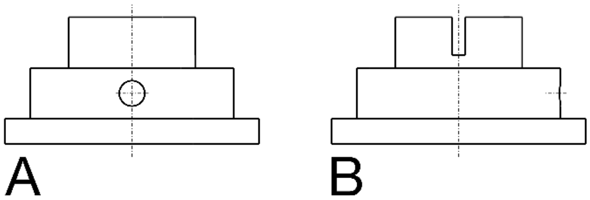
Name the three mistakes in the following section view of a thread connection.



1. Hatching of the inside thread should reach up to the core bore. (1 Point)
2. Tip of the core bore is missing. (1 Point)
3. Usable thread length of the screw should be a thick line. (1 Point)

Question 2:
Which of the views shown corresponds to the projection of the spatial represented body in the direction of the arrow? Mark the answer with a cross.

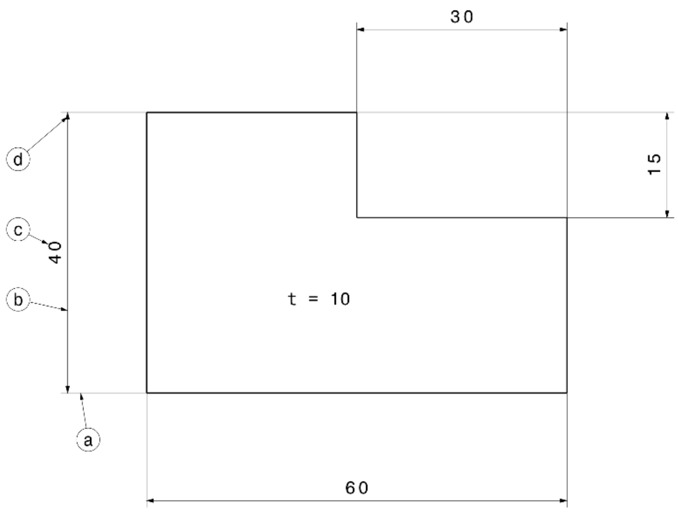




☐ A ☐ B (1 Point)

Question 3:

Name the marked elements of a dimension:



a: Extension Line (1 Point)

b: Dimension Line (1 Point)

c: Dimension Text/Value (1 Point)

d: Boundary of Dimension Line (1 Point)

Question 4:

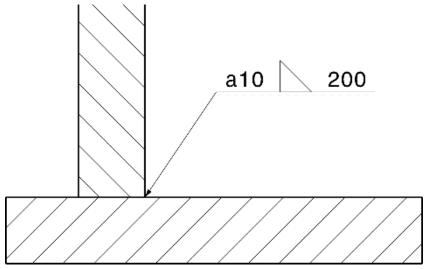
What is the resulting volume in dm³ of the body shown in the previous question?

V = (40mm * 60mm * 10mm) – (30mm * 15mm *10mm) = 0.0195 dm^3 (2 Points)

Tolerances and Additional Markings	(/)

Question1:

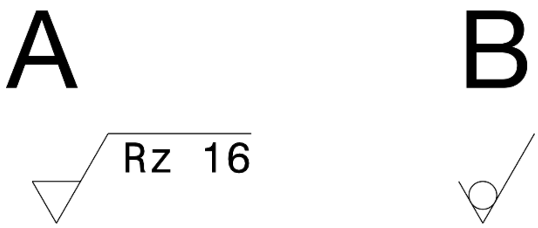
Which information can you derive from the following drawing:



Fillet Weld with thickness 10 mm (1 Point)
Length of the weld: 200 mm (1 Point)

Question 2:

Which information can you derive from the following surfaces?



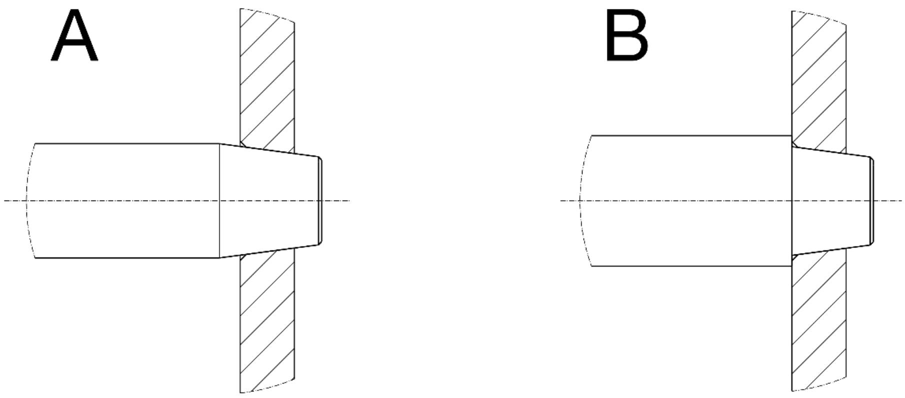
A: Surface processed with material removing methods (1 Point)
Mean roughness 16 µm (1 Point)

B: Surface where no material removal is allowed (0.5 Points)
No further information on the surface roughness (0.5 Points)

Compliant Design	(/)

Question 1:

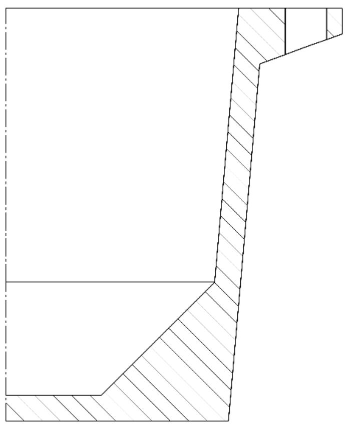
Which seating of the bolt would you prefer and why?



Seating A, because here the connection is statically defined and not over defined as in B. (1 Point)

Question 2:

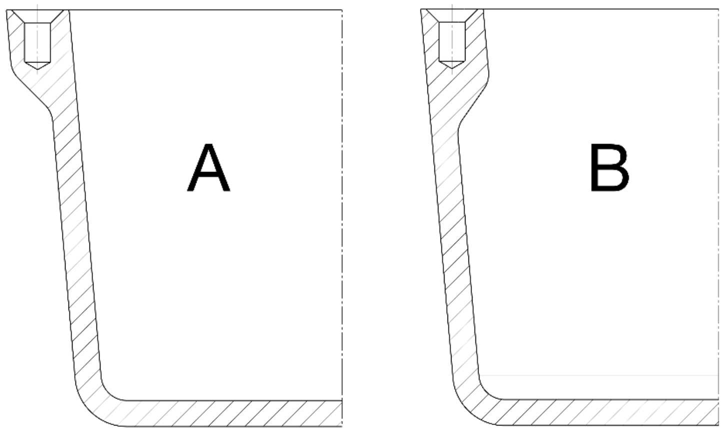
Which three mistakes are made in the following part concerning casting?



1. No round edges (1 Point)
2. Not enough surfaces perpendicular to the drill axis for entering and exiting the material with the drill (1 Point)
3. Accumulation of material at the bottom (risk of blowholes) (1 Point)

Question 3:

Which shape is better suited for casting and why?

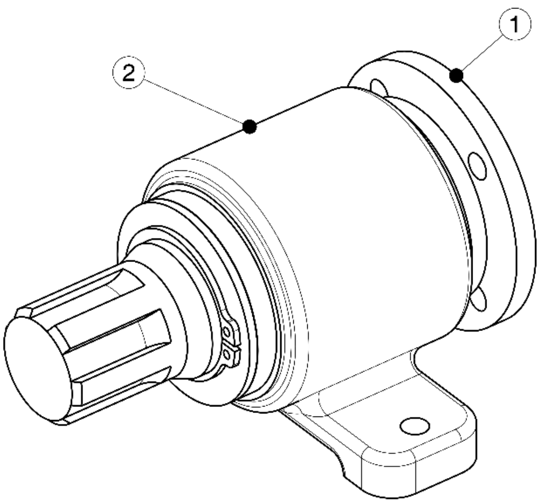


Shape A, because it has no undercuts and therefore can be casted without a lost core. (1 Point)

Drawing of Assemblies	(/)

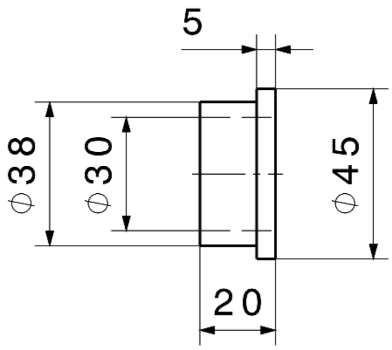
Question 1:

You are a housing (2) for a shaft (1) of a control linkage in a wing, which serves to convert a torque into a force via a lever arm.
The torque is applied via the splined shaft and the lever is flanged to the end of the shaft.
The shaft (1) is movably mounted in the housing (2) by means of plain bearing bushes. The plain bearing bushes are located between the shaft (1) and the housing (2).
Draw the full sectional view of the assembly in the given template. Make sure that the bearing is free of play and fully defined. Insert standard parts where necessary to define and secure the bearing. Lubrication does not have to be considered. You do not need to add the part with the flanks of the spline shaft of (1).

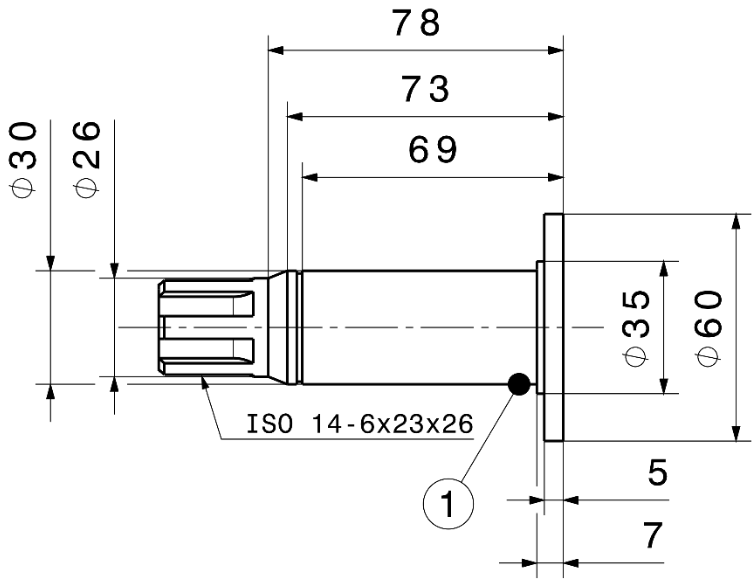


Given Parts:

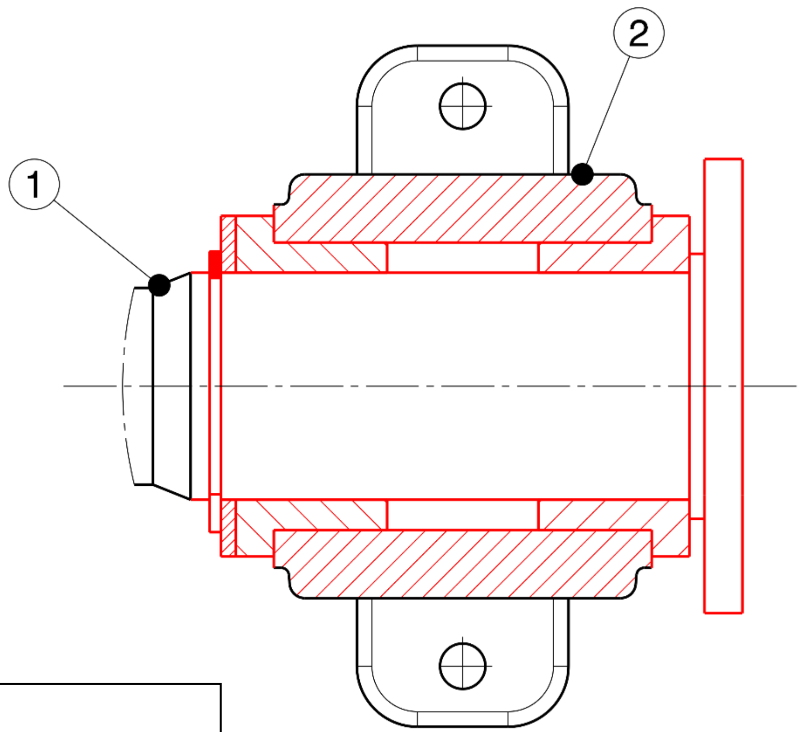
Plain Bearing M1:2



Shaft, M1:2



Drawing (1:1):



Points:

- Plain Bearings (2 Points)
- Shaft (2 Points)
- Housing (1 Points)
- Hatching (1 Points)
- Shim (1 Points)
- Circlip (1 Points)

<u>Question 2:</u>

Mark all relevant <u>press fits</u> and <u>loose fits</u> in the sectional view.

Press fit: Between housing and plain bearings (1 Point)
Loose fit: Between plain bearings and shaft (1 Point)