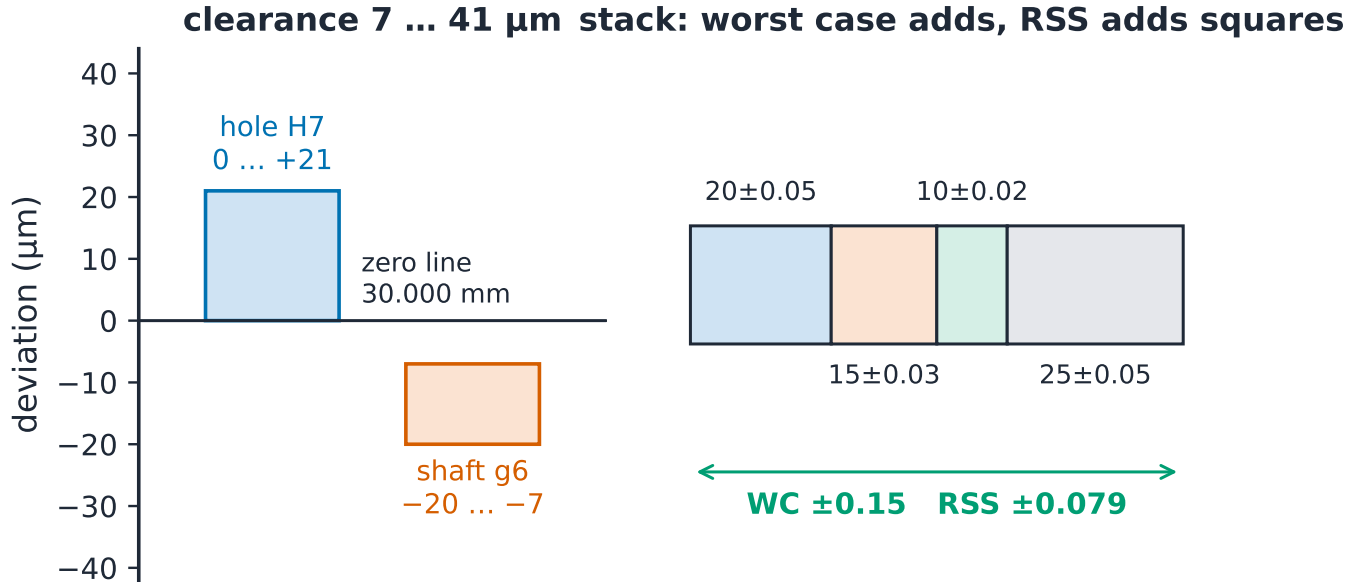
Exercise walk-through

8.1 Engineering drawings and tolerances

University Mechanical Engineering

Fits: the shaft must turn, not rattle



30 H7/g6 gives a clearance of $\mathbf{7}$ to $\mathbf{41}$ µm; four spacers stack to $\pm\mathbf{0.15}$ worst case, $\pm\mathbf{0.079}$ RSS.

Worst case or RSS?

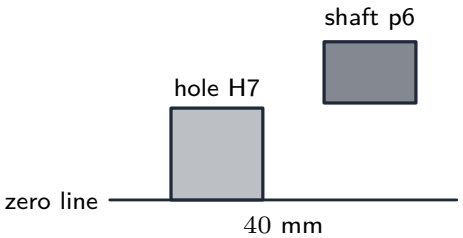
1. **Chain** Spacers 20 ± 0.05, 15 ± 0.03, 10 ± 0.02, 25 ± 0.05 plus a bore depth ± 0.04.
2. **Worst case** $\pm(0.05 + 0.03 + 0.02 + 0.05 + 0.04) = \pm\mathbf{0.19}$ mm.
3. **RSS** $\pm\sqrt{0.05^2 + 0.03^2 + 0.02^2 + 0.05^2 + 0.04^2} = \pm\mathbf{0.089}$ mm.

Decision

Worst case when one failure is unacceptable; RSS for high volume with capable processes.

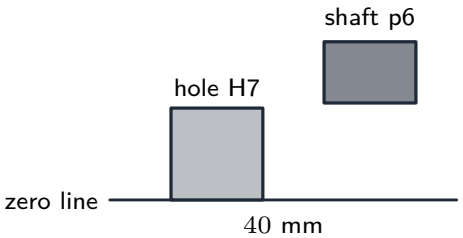
Exercise 2.1

2.1 Find the limits of a 40 H7/p6 fit and the smallest and largest interference. Say what this fit is used for. [3]



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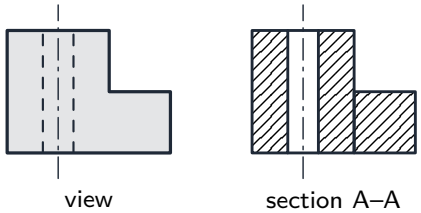


2.1

hole 40.000 to 40.025; shaft 40.026 to 40.042; interference 0.001 to 0.042 mm; a press fit, for a bush or gear that must not move on its shaft

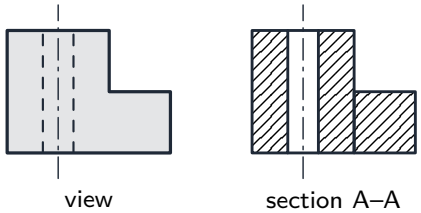
Exercise 2.2

2.2 On the drawing, say what the dashed lines, the chain line and the hatched area show. [2]



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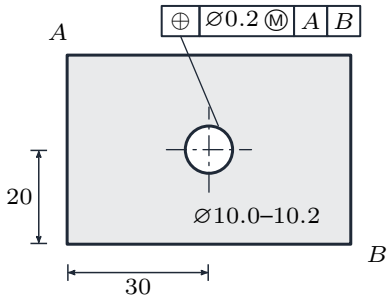


2.2

dashed: hidden edges, here the hole; chain: the axis of the hole; hatching: solid material cut by the section plane

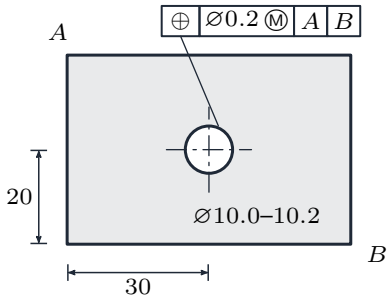
Exercise 2.3

2.3 A hole of size 10.0 to 10.2 mm has a position tolerance of ⌀0.2 at MMC. Find the position tolerance allowed when the hole is made at 10.15 mm, and explain why the bonus is fair. A hole made at its MMC size is measured at $x = 30.06$, $y = 19.92$, true position $(30, 20)$: is it in tolerance? [5]



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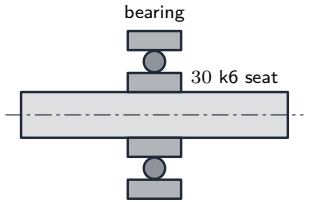


2.3

MMC is 10.0 mm; bonus 0.15 mm; allowed ⌀0.35; a bigger hole leaves more room for the mating pin, so it can be further off position and still assemble; $\varnothing = 2\sqrt{0.06^2 + 0.08^2} =$ **0.20**: exactly at the limit, accepted with no margin

Exercise 2.4

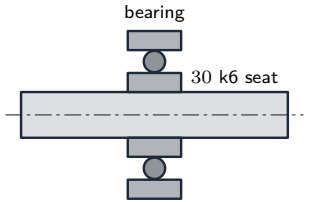
2.4 A ball bearing's inner ring has a bore of 30 mm with limits 29.990 to 30.000. It is fitted to a 30 k6 shaft.



Find the shaft limits, the smallest and largest interference, and explain why a rotating inner ring needs interference. [4][[lines:3]]

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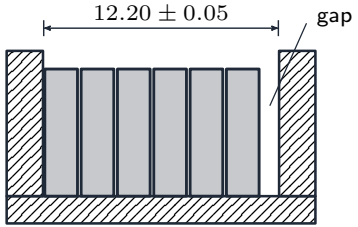
shaft 30.002 to 30.015; interference min $30.002 - 30.000 = \mathbf{0.002}$ mm, max $30.015 - 29.990 = \mathbf{0.025}$ mm

the load turns relative to the ring; with clearance the ring creeps round the shaft and wears it

Exercise 3.1

3.1 Six laminations, each 2.00 ± 0.03 mm, are packed into a slot 12.20 ± 0.05 mm wide.

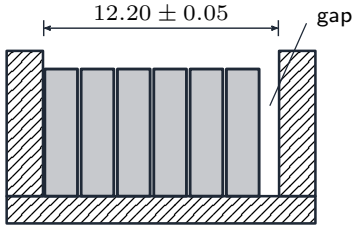
Find the nominal clearance, and its limits by worst case and by RSS. Will the pack always fit? [5]



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3.1

nominal $12.20 - 12.00 = \mathbf{0.20}$ mm

worst case $\pm(6 \times 0.03 + 0.05) = \pm 0.23$: $-\mathbf{0.03}$ to $\mathbf{0.43}$ mm

RSS $\pm\sqrt{6 \times 0.03^2 + 0.05^2} = \pm 0.089$: $\mathbf{0.11}$ to $\mathbf{0.29}$ mm

by worst case a few packs may jam; by RSS they all fit, with a very small risk

Exercise 3.2 (a)

3.2 A shaft runs in two bearings in a housing; a spacer sits between them. The end float must be 0.10 to 0.60 mm. Sizes (mm): housing width $A = 120.00 \pm 0.10$; bearings B and C, 20.00 ± 0.06 each; spacer $D = 79.50 \pm 0.05$.

(a) Find the nominal end float and its worst-case limits. [3]

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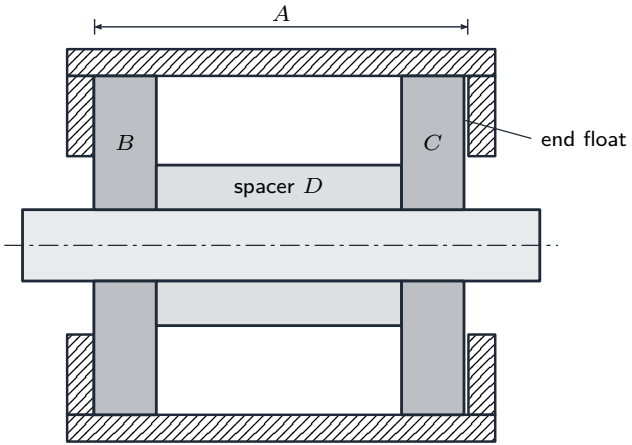
(a) $G = A - (B + C + D) = \mathbf{0.50}$ mm; $T = 0.10 + 0.06 + 0.06 + 0.05 = 0.27$; **0.23** to **0.77** mm

Setup for exercise 3.2

3.2 A shaft runs in two bearings in a housing; a spacer sits between them. The end float must be 0.10 to 0.60 mm. Sizes (mm): housing width $A = 120.00 \pm 0.10$; bearings B and C, 20.00 ± 0.06 each; spacer $D = 79.50 \pm 0.05$.

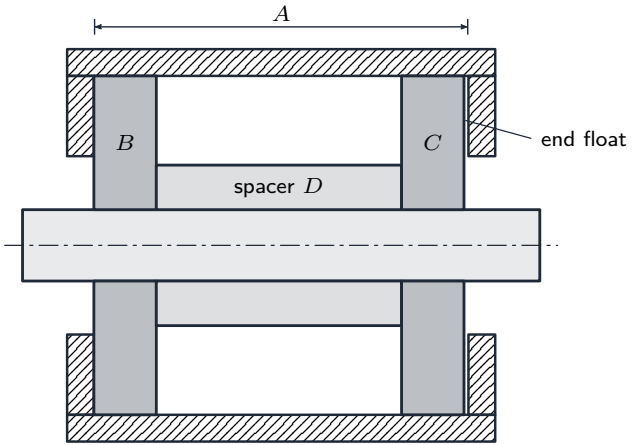
Exercise 3.2 (b)

(b) Find the RSS limits. Does the design meet the requirement? Then propose one change to the spacer that meets the requirement by RSS, and check it. Give one other way to meet it. [5]



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(b) $\pm\sqrt{0.10^2 + 2 \times 0.06^2 + 0.05^2} = \pm 0.14$: 0.36 to 0.64 mm; the top limit is over 0.60: **fails** make the spacer 79.65 ± 0.05: nominal 0.35, RSS 0.21 to 0.49 mm, inside 0.10 to 0.60; or measure at assembly and fit a selected shim