

Snap-fit & living-hinge design

Designing cantilever and annular snap-fits and integral living hinges — the strain limits, retention vs assembly force, hinge geometry, and the materials that survive.

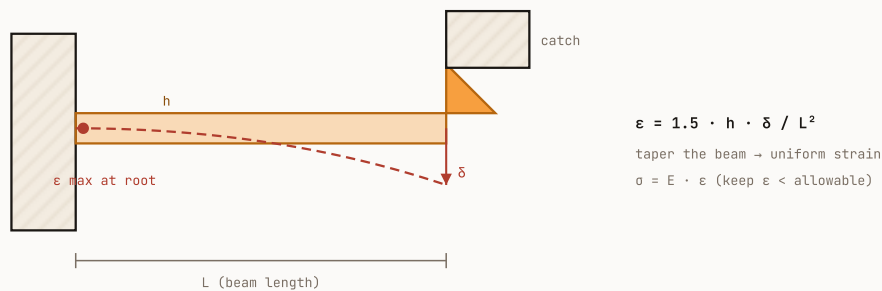
REVISION	ISSUED	OWNER	COMPANION
1.0	June 2026	Ideambox engineering	PDF reference

ABSTRACT

Snap-fits and living hinges are "free" features moulded into a plastic part that replace screws and separate hinges. They work by elastic deflection, so the whole design is a strain problem: deflect enough to assemble, but stay under the material's allowable strain so the feature doesn't break or take a permanent set.

Section 1 covers snap-fit types. Section 2 is the cantilever snap (strain, forces). Section 3 is annular (ring) snaps. Section 4 is living hinges. Section 5 is materials and moulding. Section 6 is failure modes and a checklist.

CANTILEVER SNAP-FIT – DEFLECTION & STRAIN



A CANTILEVER SNAP DEFLECTS Δ DURING ASSEMBLY; PEAK STRAIN IS AT THE ROOT, $E = 1.5 \cdot H \cdot \Delta / L^2$. KEEP THAT BELOW THE RESIN'S ALLOWABLE STRAIN AND IT SURVIVES – TAPER THE BEAM TO SPREAD THE STRAIN AND YOU CAN DEFLECT FURTHER.

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1. Snap-fit types

A snap-fit deflects during assembly, then springs back so a hook (or ring) sits behind a catch.

TYPE	ACTION	USE
Cantilever (hook)	a beam bends	the default — most snap-fits
Annular (ring)	a lip expands over a groove	caps, round bezels, sealing
Torsional	a bar twists	levers, frequently-opened latches

The **catch geometry** sets behaviour: a shallow **return (retention) angle** (~30–45°) makes it separable; a steep/90° face makes it permanent. The **lead (insertion) angle** (~20–30°) sets how easily it goes together.

Deflection δ	How far the snap moves during assembly
Strain ϵ	Local stretch at the beam root — the value you limit
Allowable strain	Max strain the resin tolerates (one-time vs repeated use)
Retention angle	Catch face angle — low = easy release, 90° = permanent

2. Cantilever snap

For a constant-section cantilever, the peak strain is at the **root**:

$\epsilon = 1.5 \cdot h \cdot \delta / L^2$ (h = beam thickness, L = length, δ = deflection), and stress $\sigma = E \cdot \epsilon$.

- Keep $\epsilon \leq$ allowable (below). Taper the beam (thinner or narrower toward the tip) to even out the strain
a tapered snap can deflect $\sim 2\times$ further for the same peak strain.
- Assembly force \approx the beam's deflection force \times (tan of lead angle + friction); retention force uses the steeper return angle.
Lower the lead angle for easier assembly; raise the return angle for stronger hold.
- Longer/thinner beams deflect easily (low strain) but hold less; it's a balance. Use the Snap-fit stress tool to size it.

RESIN	ALLOWABLE STRAIN, ONE-TIME	NOTES
ABS	2–3%	tough, easy default
PC	$\sim 2\%$	strong but notch-sensitive
PP	5–6%	very flexible, forgiving
PA (nylon)	2.7–3.5%	strong; moisture changes it
POM (acetal)	6–8%	excellent snap material
PE	$\sim 5\%$	flexible, low modulus

For **separable / repeated** snaps, design to $\approx 60\%$ of the one-time allowable (and even less for many cycles).

3. Annular (ring) snaps

A ring snap expands a lip over a mating groove (bottle caps, round housings):

- **Sizing is by hoop strain = (expansion diameter – groove diameter) / groove diameter**
keep it under the material allowable.
- **Full rings are stiff (high retention, high assembly force); segmented rings (slots) reduce both and ease assembly.**
- **Good for sealing and symmetric retention; combine with an O-ring groove where a seal is needed.**

4. Living hinges

A living hinge is a thin web moulded integrally — millions of cycles if designed right, but only in the right resin:

- **Material:** PP or PE only (or PP copolymer). Other resins crack. PP is the standard.
- **Geometry:** web thickness 0.25–0.5 mm, a generous inside radius (~0.4–0.6 mm), and a short land; the thin section must flex, not stretch.
- **Process:** gate so the flow crosses the hinge (molecular orientation along the hinge dramatically boosts fatigue life), and flex the hinge once immediately after moulding while warm to set the orientation.
- **Keep the hinge thin and consistent; thick or uneven webs fatigue and whiten.**

5. Materials and moulding

- **Snaps: POM and PP are the most forgiving; ABS and PA are common; PC needs care (notch-sensitive radius the root).**

- **Always radius the beam root**
a sharp inside corner is a stress raiser that halves snap life.

- **Respect draft and ejection**
snaps often need a slide, lifter, or a clever parting line to mould and eject.

6. Failure modes and checklist

MODE	CAUSE	FIX
Breaks on assembly	strain > allowable, sharp root	longer/tapered beam, root radius, tougher resin
Loses retention (creep)	held deflected, warm, soft resin	don't preload the snap, design for zero standing strain
Fatigue (repeated use)	strain too high for cycle count	design to \ll allowable, taper, POM/PP
Living-hinge cracks/whitens	wrong resin, thick/uneven web, bad gate	PP/PE, 0.25–0.5 mm web, flow across hinge, flex while warm

Checklist: type (cantilever / annular / torsional) → set δ from assembly travel → size L, h so $\epsilon = 1.5h\delta/L^2$ is below allowable ($\approx 60\%$ for reusable) → radius the root, taper the beam → choose return/lead angles for permanent vs separable → for hinges use PP/PE, 0.25–0.5 mm web, flow across the hinge.