Design in practice

International Baccalaureate · IB Diploma · Design Technology · HL

Scope and prerequisites

This handout covers selected HL topics for the course first assessed in 2027; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

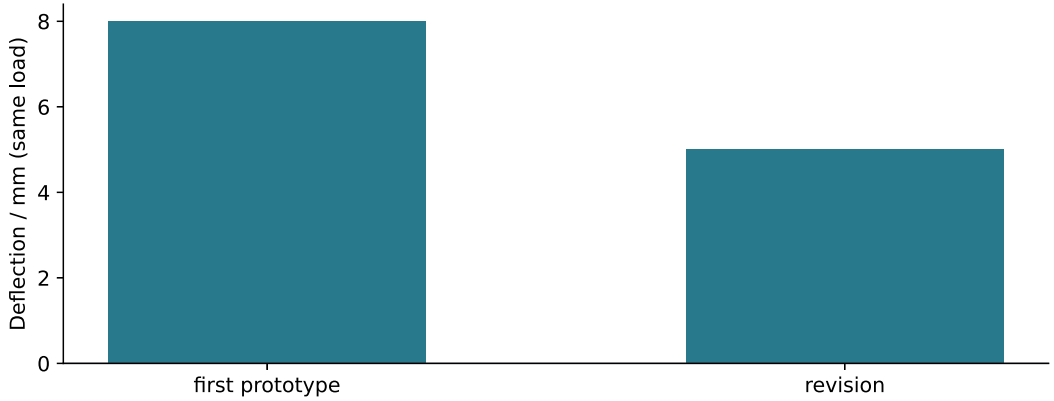
Models, materials and iterative prototyping

What would explain this observation?

- A cardboard **prototype** can reveal reach and arrangement without proving that the final material is strong enough. Different models answer different questions.

Build the model

- A model represents selected features of a design.
- A prototype supports testing before or during development.
- Material selection depends on mechanical properties, manufacture, use conditions and end-of-life choices.
- prototype: A developing version used to test a solution.
- **iteration** : Revision guided by evidence and repeated testing.



Deflection falls from 8 mm to 5 mm under the same load: a 3 mm, 37.5% reduction

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Choose evidence that can test it

- State what each model includes and omits.
- Compare tests with the same load, geometry and conditions.
- Iteration means using evidence to revise a solution and testing the revision against the original success criteria.

In the lab: Make a low-risk model under school workshop rules. Record dimensions, material, process and test method. Use photographs, measurements and user feedback as evidence. Machines and load tests require teacher supervision and approved guards.

Work from known quantities

- Known: a beam prototype deflects 8 mm under a stated load; a revision deflects 5 mm under the same conditions.
- Reduction = (8-5)/8×100 = 37.5%.
- The result supports greater stiffness in that test, not proof of every strength or fatigue property.

Your turn: Deflection falls from 10 mm to 6 mm under equal conditions. Find percentage reduction.

Check the conclusion and its limits

- Stiffness is resistance to elastic deformation; strength concerns failure stress.
- A visually accurate model need not reproduce material behaviour.

Not true: An attractive model proves the final product mechanical safety. Appearance is not performance. Mechanical safety depends on material, geometry and manufacturing; a good-looking model proves only that the design looks right.

Key:

- A model represents selected features of a design.
- State what each model includes and omits.
- Watch for: stiffness is resistance to elastic deformation; strength concerns failure stress.

Write from a 25 percent reduction

- A beam deflects 12 mm. A revision deflects 9 mm under the same load, geometry and conditions.
- Find the percentage reduction. Cardboard can test arrangement without proving the final material.

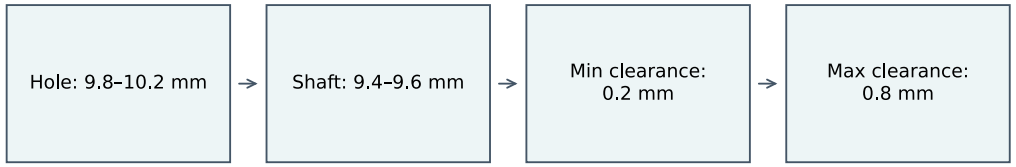
Manufacture: tolerances, variation and inspection

What would explain this observation?

- Two parts can each match a nominal drawing yet fail to assemble if allowed variation has not been considered. Manufacture produces a range of dimensions.

Build the model

- A **tolerance** specifies an allowed dimensional range around or beside a nominal value.
- Precision concerns consistency of repeated measurements or production, while accuracy concerns agreement with a reference.
- Process selection must consider material, geometry, quantity, surface finish, waste and achievable variation rather than appearance alone.
- tolerance: The allowed range of variation in a specified dimension.
- **clearance** : The dimensional space between mating parts under the stated model.



Minimum clearance = smallest hole − largest shaft = 0.2 mm; maximum = largest hole − smallest shaft = 0.8 mm

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Choose evidence that can test it

- For a worst-case clearance model, subtract the largest shaft from the smallest hole for minimum clearance, and the smallest shaft from the largest hole for maximum clearance.
- The calculation assumes the stated dimensional limits and ideal geometry.
- Shape, alignment, temperature and measurement uncertainty can affect actual assembly.

In the lab: Use safe school-made models or a provided dimension dataset. Specify dimension units, nominal values and limits before testing. Measure with an appropriate calibrated instrument at agreed positions, record every result and classify against the specified range. Retain rejected pieces and explain whether the problem concerns the design limits, process variation or measurement method.

Work from known quantities

- Known: a hole is 10.0±0.2 mm, giving 9.8–10.2 mm; a shaft is 9.5±0.1 mm, giving 9.4–9.6 mm.
- Minimum clearance is 9.8−9.6=0.2 mm and maximum is 10.2−9.4=0.8 mm.
- This model predicts positive clearance across the stated limits.
- It does not establish strength or fitness for a safety-critical application.

Your turn: A hole ranges from 12.0 to 12.4 mm and a shaft from 11.5 to 11.8 mm. Calculate minimum clearance.

Check the conclusion and its limits

- A tighter tolerance can increase cost, inspection time and waste, and may not improve the user outcome.
- A measuring instrument with a fine display does not automatically have the accuracy required to accept a part near its limit.

Not true: A finer instrument display guarantees sufficiently accurate dimensional inspection. Display resolution is not accuracy: an instrument can show 0.001 mm while being systematically off by far more. Inspection near a tolerance limit needs a calibrated instrument with proven accuracy.

Key:

- A tolerance specifies an allowed dimensional range around or beside a nominal value.
- For a worst-case clearance model, subtract the largest shaft from the smallest hole for minimum clearance, and the smallest shaft from the largest hole for maximum clearance.
- Watch for: A tighter tolerance can increase cost, inspection time and waste, and may not improve the user outcome.

Write from a minimum clearance of 0.1 mm

- A hole ranges from 20.0 mm to 20.3 mm. A shaft ranges from 19.6 mm to 19.9 mm.
- Find the minimum and maximum clearance. The limits do not prove strength.

■ **Write from a Young modulus comparison**

- Two beams have the same shape; one material is three times stiffer.
- Under the same load the stiff beam deflects one-third as much – stiffness is a MATERIAL choice; deflection also follows shape, so change one at a time.

■ **Write from a tolerance stack**

- Three parts in series each may be 0.1 mm off.
- The assembled length may be off by up to 0.3 mm – tolerances STACK along a chain, which is why assemblies specify the worst case.