

# The elemental Gordian knot

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# Modern material discoveries



# Materials case study: rubber

Potential energy in elastic band

$$E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} 10 \times 0.1 = 0.5 \text{ J}$$



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Kinetic energy in handgun bullet

$$E = \frac{1}{2} mv^2 = \frac{1}{2} 0.005 \times 300^2 = 225 \text{ J}$$



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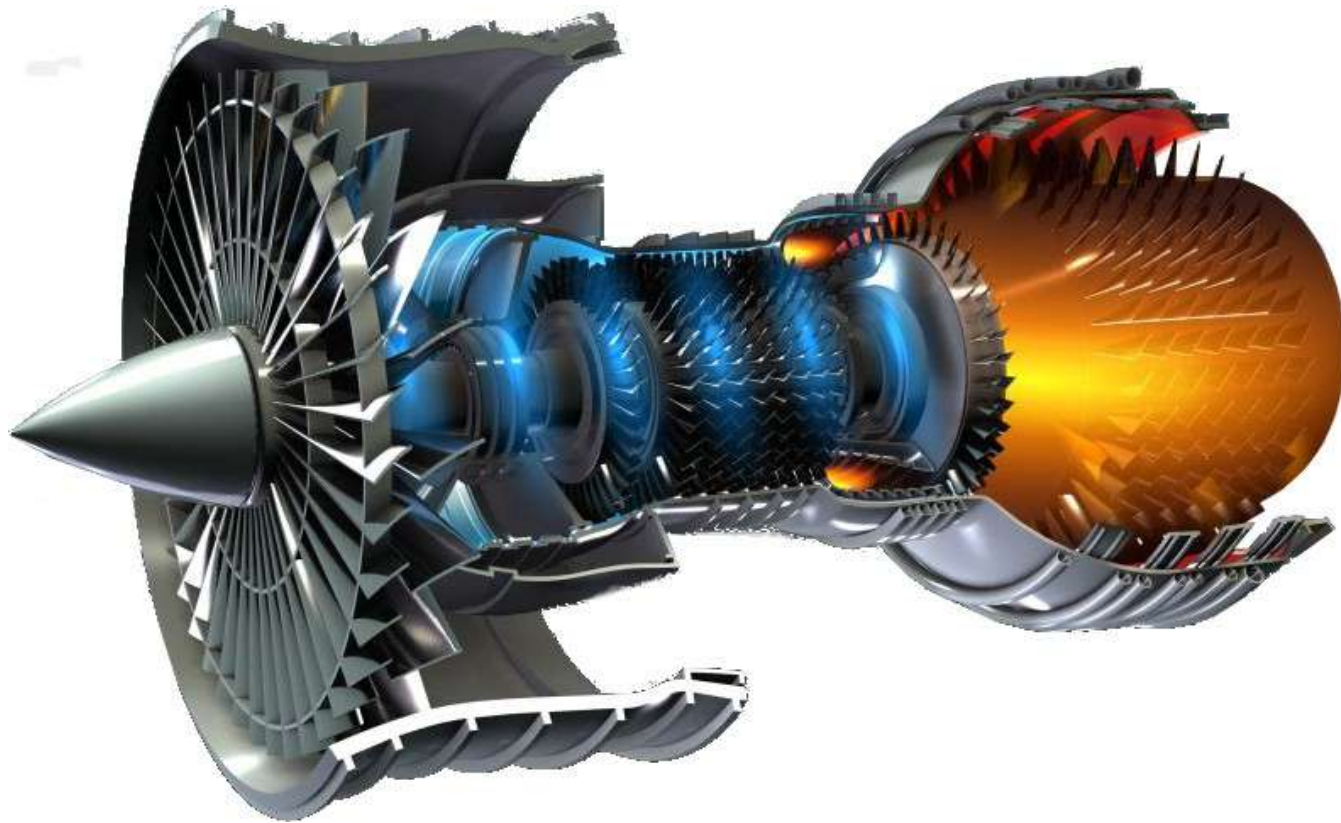
$$E = \frac{1}{2} mv^2 = \frac{1}{2} 0.005 \times 300^2 = 225 \text{ J}$$

Potential energy in enormous band

$$E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} 100 \times 5 = 250 \text{ J}$$

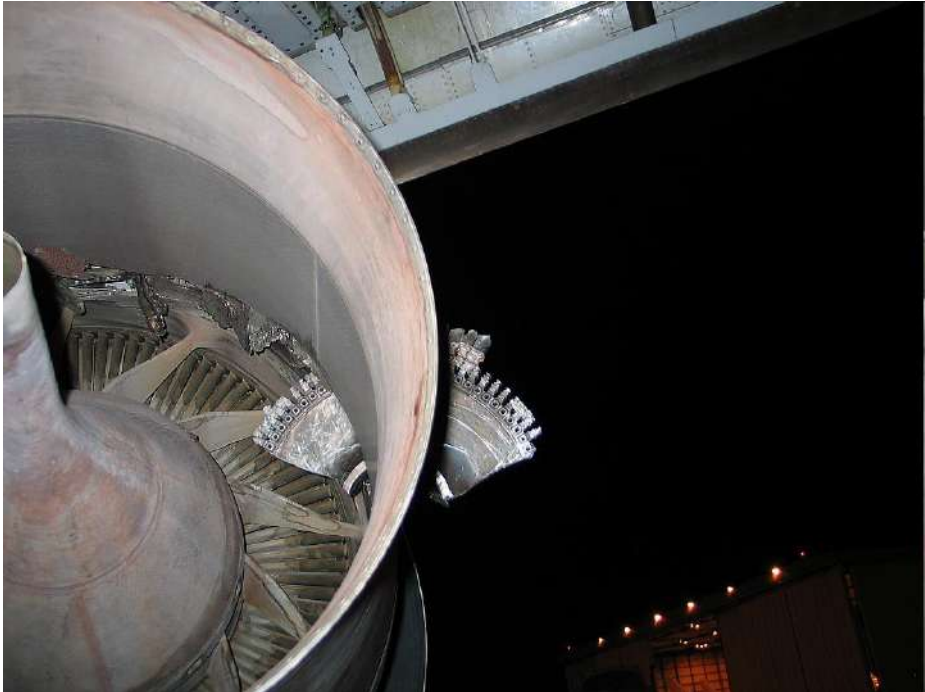


# Jet engine



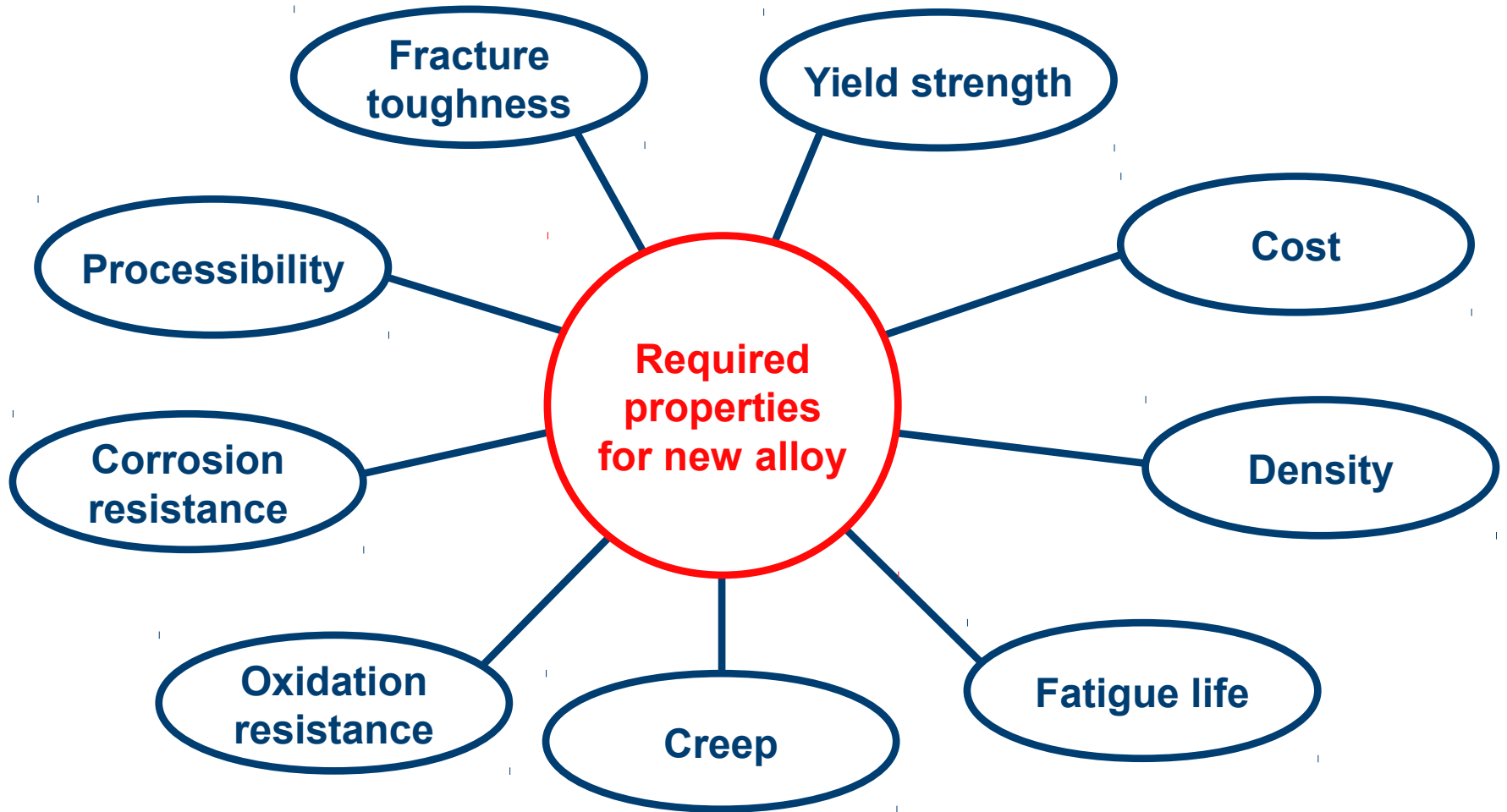


# Jet engine: turbine discs





# Designing a new alloy – what is required ?



# Multidimensional design space

**Cr**



**Co**



**Mo**



**W**



**Ta**



**Nb**



**Al**



**Ti**



**Fe**



**Mn**



**Si**



**C**



**B**



**Zr**



**Cu**



**N**



**P**



**V**



**Hf**



**Mg**



**Ni**

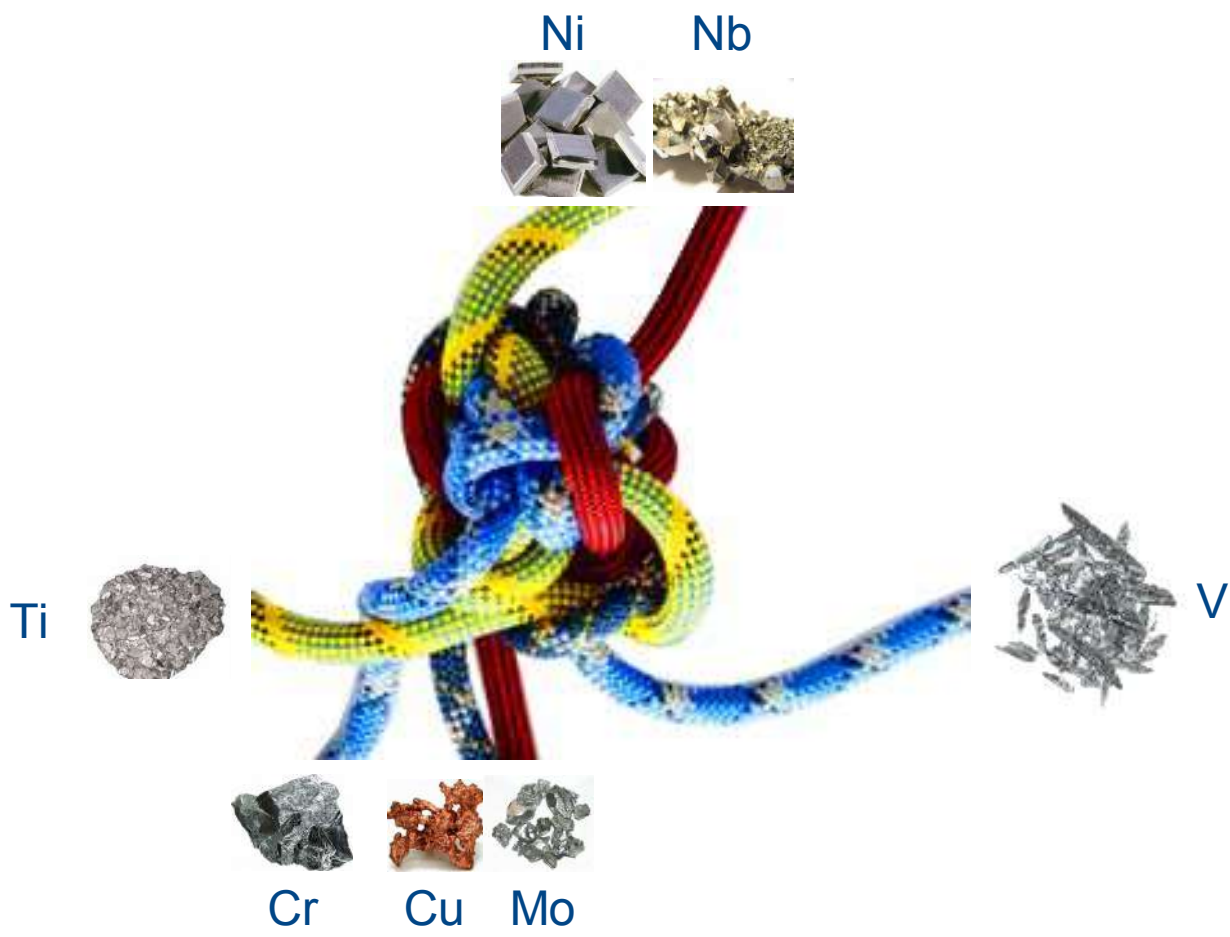


and 4 different manufacturing processes

# The Gordian knot

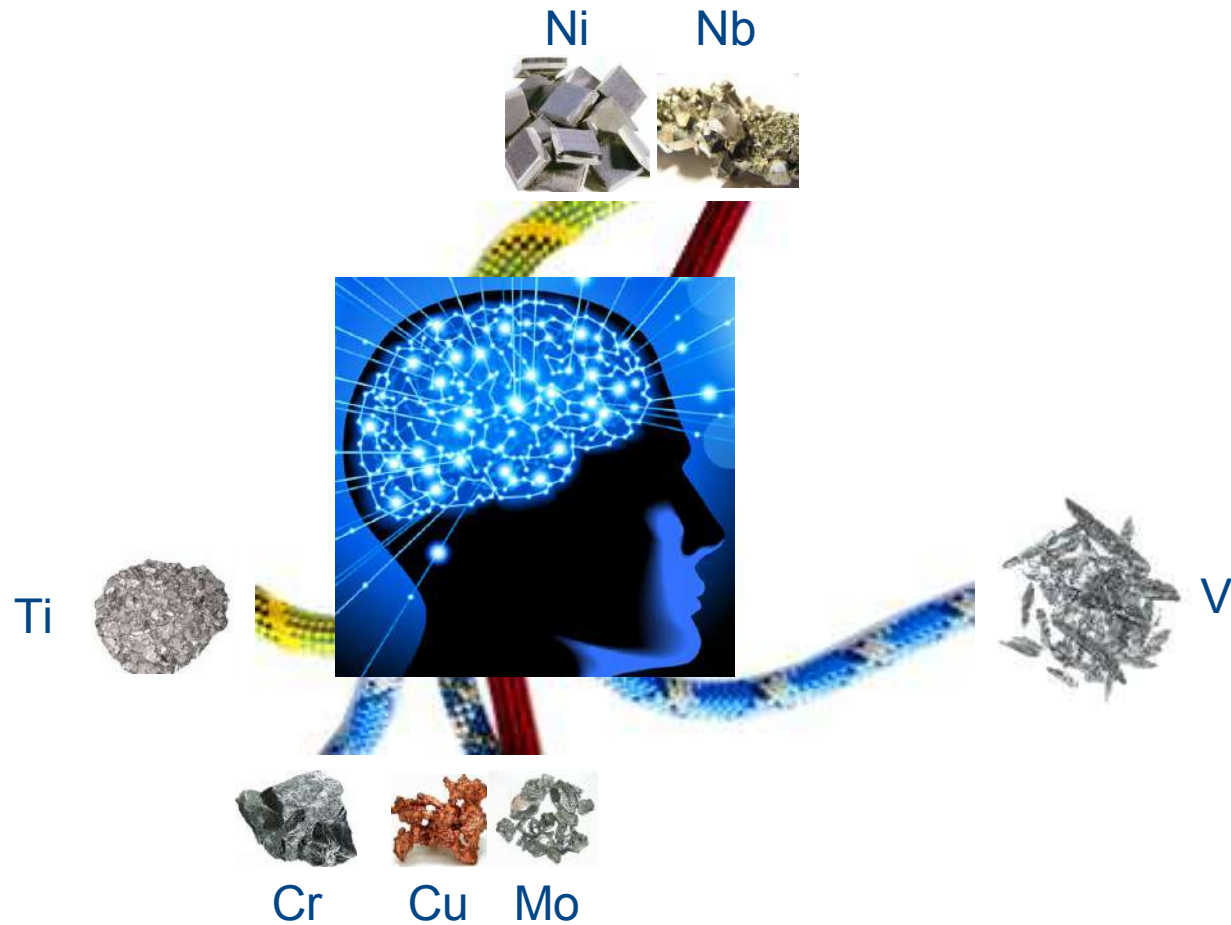


# The elemental Gordian knot





# Untangling the elemental Gordian knot



# Training the neural network



Natural Sciences Tripos Part III

Master of Advanced Study in Materials Science

Friday 30 May 2014

13.30 to 16.30

MATERIALS SCIENCE (3)

Answer **five** questions, attempting **either** (a) or (b) from each.

Each question is worth **equal** credit.

Percentages in the right margin indicate the **approximate** credit allocated to each part of a question.

Write on **only one** side of the paper.

The answer to **each** question must be tied up **separately**, with its own cover-sheet.

Write the relevant **question number** in the square labelled 'Section' on each cover-sheet.

List the numbers of **all** questions attempted from this paper on **each** cover-sheet.

**STATIONERY REQUIREMENTS**

Graph paper x 2 sheets

Lined paper x 20 sheets

Cover sheets x 5

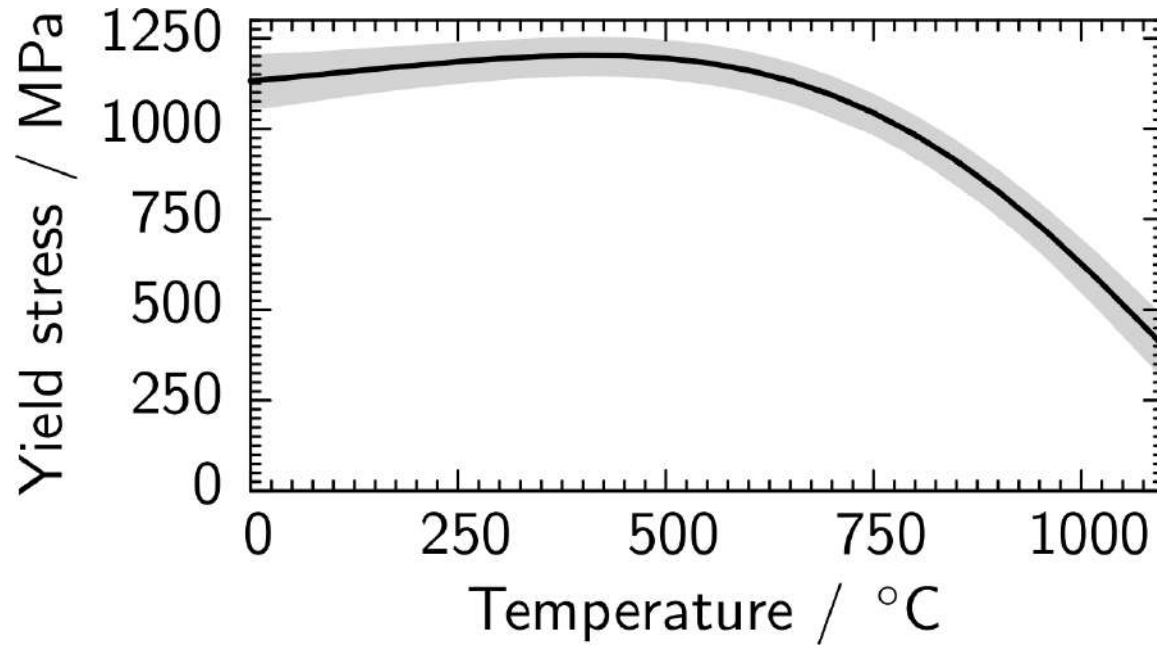
Treasury tags

**SPECIAL REQUIREMENT**

Part II / III Data Book

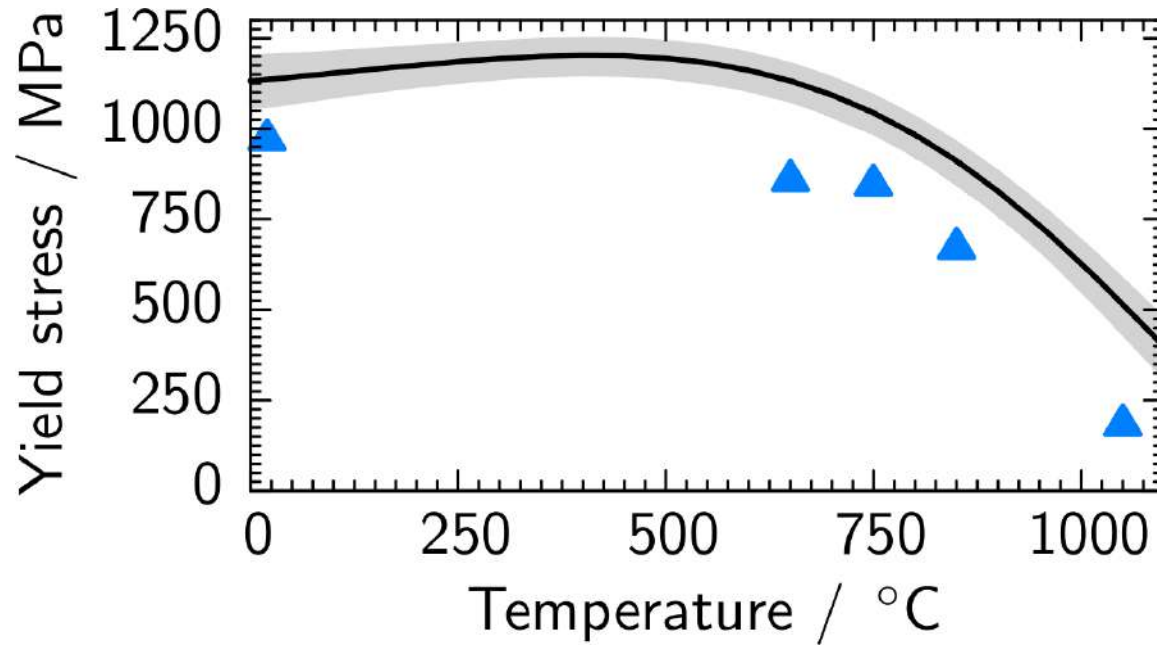
**Do not read the questions printed on the subsequent pages until instructed that you may do so by the Invigilator.**

# Testing the yield stress

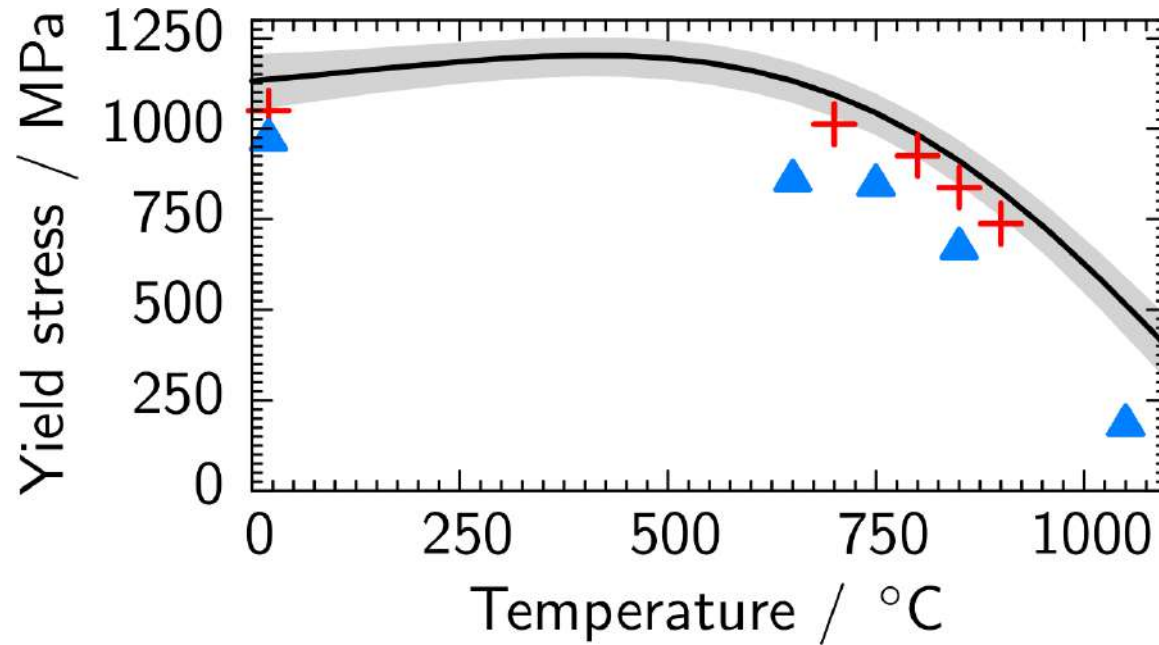




# Testing the yield stress



# Testing the yield stress



# Summary

Used artificial intelligence to discover new materials

Discovered four new alloys, experimentally verified their properties, 12 patents

Further work with Rolls-Royce plc, Samsung, Granta Design, BP plc