Alloys by design

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- Kinetic energy in handgun bullet:
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- Kinetic energy in handgun bullet:
  \[ E = \frac{1}{2} mv^2 = \frac{1}{2} 0.005 \times 400^2 = 400 \text{ J} \]

- Potential energy in enormous band:
  \[ E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} 100 \times 10 = 500 \text{ J} \]
Alloys – where are they used?
Jet engine: military jet
Jet engine: commercial jet
Jet engine: turbine discs
Certification – fan blades & birds!

- **Small bird**: Number based on area of front of engine, maximum 16, mass 55 - 110g (e.g. starlings)
- **Medium bird**: Number based on area of front of engine, maximum 10, mass 0.7 kg (e.g. seagull)
- **Large bird**: 1 bird, mass at least 1.8 kg at speeds up to 2500ms$^{-1}$
Aircraft fuel efficiency over the past 50 years

![Graph showing fuel efficiency improvements over time](image-url)
Designing a new alloy – what is required?

Required properties for new alloy:
- Fracture toughness
- Yield strength
- Processibility
- Cost
- Density
- Fatigue life
- Corrosion resistance
- Oxidation resistance
- Creep
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Types of property models

• For efficient development, predictions must take seconds or less
  ✗ Experimental data (weeks/months)
  ✓ Neural networks (nano/micro seconds)

• Combine estimates of individual properties to give overall probability of success
Multidimensional design space

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and 4 different manufacturing processes
Selection of design space
Selection of design space
Automated sampling - parallel optimization
Predicted material

- Processed according to model predictions
- Property assessment underway
Conclusions: scientific

- Developed new algorithms to optimize a material’s properties
- Manufactured proposed alloy with testing underway
Conclusions: why work in material sciences?

- Varied roles that combine analytics, numerics, and experiments
- Close connection to real-world problems
- Strong academic funding and well-paid industrial jobs