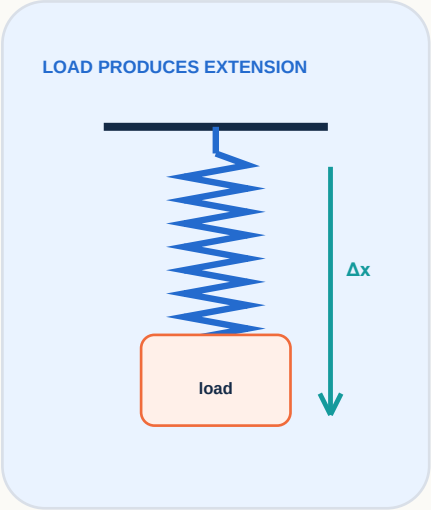
PEARSON EDEXCEL IAL PHYSICS | UNIT 1

# LESSON 1.2.2

## Hooke's Law and Elastic Behaviour

Within the proportional region, force and extension change together. Beyond key limits, the object may no longer return to its original shape.




### THE CORE RELATIONSHIPS

**HOOKE'S LAW**

$\Delta F = k\Delta x$

**STIFFNESS**

$k = \Delta F / \Delta x$

**PROPORTIONALITY**

straight-line graph

### FOUR LANDMARKS ON THE GRAPH

**LIMIT OF PROPORTIONALITY**

The force-extension graph stops being a straight line through the origin.

**ELASTIC LIMIT**

Beyond this point, removing the force leaves permanent deformation.

**YIELD POINT**

A large increase in extension occurs for a relatively small force increase.

**PLASTIC DEFORMATION**

The object does not fully return to its original dimensions when unloaded.

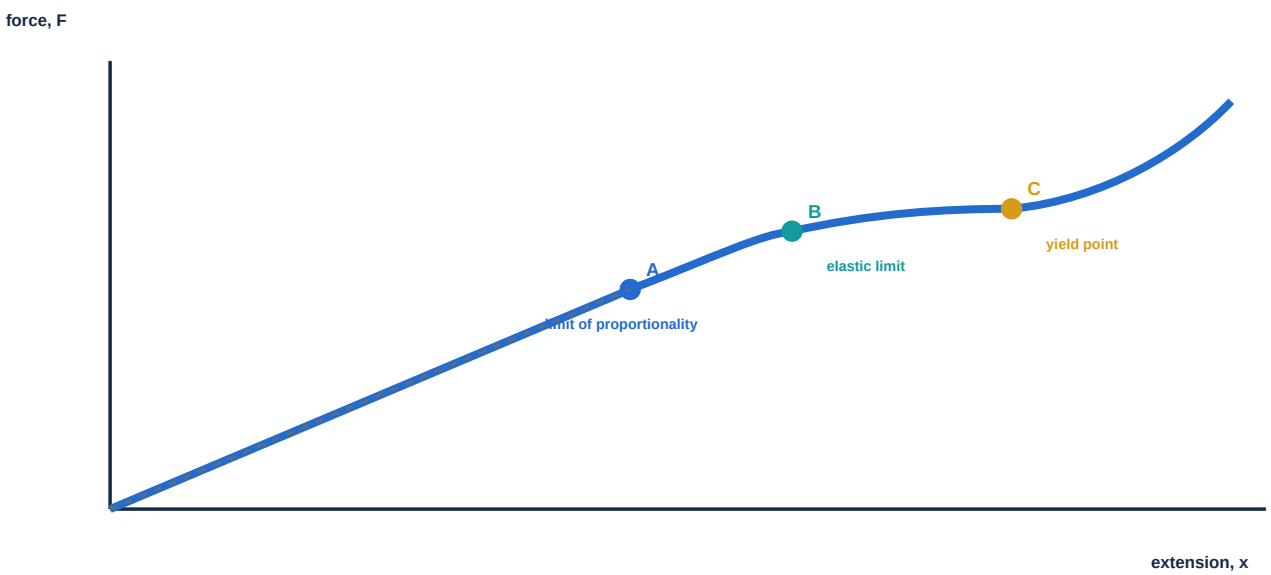
**CORE HABIT**

State the graph region before using Hooke's law. A straight line through the origin is the visual test for proportionality.

# 1 Hooke's law and force-extension graphs

Stiffness is the gradient in the proportional region. The graph then reveals where elastic behaviour ends and plastic behaviour begins.

## READ THE GRAPH IN REGIONS




## THE LINEAR REGION

$$k = \frac{\Delta F}{\Delta x}$$

unit: N m$^{-1}$

**gradient of F against x = stiffness, k**

steeper graph = stiffer object

## WORKED EXAMPLE

A spring has k = 200 N m$^{-1}$ and extends by 0.030 m.

$$\Delta F = k\Delta x = (200)(0.030) = 6.0 \text{ N}$$

**DO NOT CONFUSE THE LIMITS**

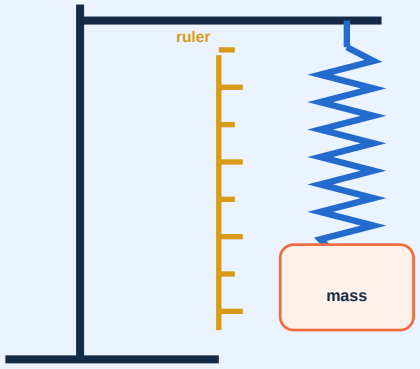
**After the limit of proportionality, the graph is non-linear. The object may still be elastic until the elastic limit is exceeded.**

2

# Investigating stiffness and deformation

Measure extension for a series of loads, plot force against extension, and use the graph to judge stiffness and elastic behaviour.

## A RELIABLE SPRING INVESTIGATION




1. Measure the original length with no added load.
2. Add known masses gradually and calculate force using F = mg.
3. Record extension, not total length, after oscillations stop.
4. Plot F on the vertical axis against extension x on the horizontal axis.
5. Use the linear best-fit gradient for k; do not use data beyond proportionality.

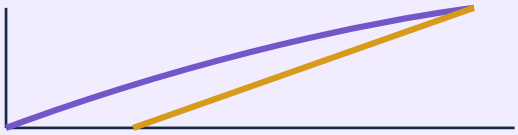
## WHAT HAPPENS ON UNLOADING?

ELASTIC



returns to origin

PLASTIC



permanent extension

## QUALITY OF DATA

**ZERO ERROR**

Check the ruler reading before loading.

**PARALLAX**

Read the scale at eye level with a fixed pointer.

**SAFETY**

Do not overload the spring or stand beneath falling masses.

### GRAPH INTERPRETATION CHECKLIST

1. Check both axes, units and whether the graph passes through the origin.
2. Use only the straight-line region when calculating stiffness from the gradient.
3. Compare loading and unloading to decide whether deformation is elastic or plastic.