It has been fully revised and updated for the new A Level specifications for first teaching from September 2020, and is suitable for AQA, OCR, WJEC and Edexcel. The textbook provides plenty of examples and practice questions for consolidation of learning. Additional sections in the textbook provide help with revision and exam technique, practical skills and maths skills.
The **momentum** of an object depends on its **mass** and its **velocity**.

**In fact:**

\[ \text{Momentum} = \text{mass} \times \text{velocity} \quad \text{(kg)} \times \text{(m/s)} \quad \text{or} \quad \text{Momentum} = mv \]

Momentum is a **vector** quantity. It is measured in units of **kg m/s**.

A bicycle of mass 10 kg moving at 5 m/s has a momentum of 50 kg m/s.

Consider a force \( F \) acting on a mass \( m \) for a time \( t \) so that it accelerates from velocity \( u \) to velocity \( v \).

From page 131, acceleration \( a = \frac{v - u}{t} \).

\[ \text{:. Newton's Second Law (page 134) is:} \quad F = ma = m \left( \frac{v - u}{t} \right) = \frac{mv - mu}{t} \]

or in words:

\[ \text{Force} = \frac{\text{change in momentum}}{\text{time taken for the change}} \quad \text{(N)} = \frac{\text{momentum after} - \text{momentum before}}{\text{time taken for the change}} \]

or, multiplying both sides by time, we get: \( \text{Force} \times \text{time} = \text{change in momentum} \)

**Example 1**

Consider first a boy kicking a **stone** of mass 1 kg and accelerating it from rest to 10 m/s. Because the stone is rigid, the force of his foot acts for only \( \frac{1}{100} \) second. Calculate this force.

**Formula first:** \( \text{Force} = \frac{\text{momentum after} - \text{momentum before}}{\text{time taken}} \)
Physics at work: Heat engines

4-stroke petrol engine
A car or motor-bike uses an internal combustion engine. In a petrol engine, the petrol vapour is squeezed and then exploded. The chemical energy of the fuel and air is transferred to kinetic energy (and thermal energy). However it is only about 25% efficient. The 4 steps are:

1 Suck
  The inlet valve is open and the piston is moving down. A mixture of petrol vapour and air is sucked in (or injected under pressure).

2 Squeeze
  The valves close and the piston moves up to squeeze the mixture of petrol and air to about 1/8th of its original volume. So it gets hotter.

3 Bang
  An electric spark from the sparking plug ignites the mixture which burns rapidly and expands, forcing the piston down.

4 Blow
  The exhaust valve is open and the piston is moving up, to push out the waste gases. The cycle then begins again.

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Brain Map: Geometrical Optics

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Jet engine
A jet engine also has 4 stages to transfer energy from a chemical store to a kinetic store.

1. Suck
   1. Air sucked in

2. Squeeze
   2. Air squeezed by compressor fans

3. Burn
   3. Fuel squirted in, burns continuously

4. Blow
   4. Burnt gases blow out of the back like a blowtorch and push the engine forward (they also turn a turbine fan which keeps the compressor fan turning)

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Class 12
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Brain Map: Work, Energy and Power

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CBSE Drill: Dual Nature of Radiation and Matter | Atoms | Nuclei

Monthly Tune Up: Electromagnetic Waves and Optics

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Tips Corner

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Live Physics

Crossword

DECEMBER 2020

Class 11

Focus NEET / JEE: Mechanical Properties of Solids and Fluids

CBSE Drill: Oscillations and Waves

Monthly Tune Up: Mechanical Properties of Solids and Fluids

Brain Map: System of Particles and Rotational Motion

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Machines transfer energy from one store to another. We know that the total amount of energy put into a machine must equal the total amount of energy output. This is the principle of conservation of energy (see page 102). However, only some of the output energy is useful to us. The rest is wasted energy. This affects the efficiency of the machine.

A car is not very efficient. For every 100 joules of energy (in fuel) that is put into the car, only 25 J appear as useful energy to move the car. The other 75 J is wasted as thermal energy. It is low-grade energy and we cannot use it. The efficiency is calculated by:

\[
\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \quad \text{or} \quad \text{Efficiency} = \frac{\text{useful power output}}{\text{total power input}}
\]

**Example 1**
For this car, the efficiency = \(\frac{25}{100} = 0.25 \) or 25%.

Because of friction in a machine there is always some wasted energy. This means the efficiency is always less than 100%.