4 Mechanics 1 – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	**Write it 3 times** (English)		
Newton's laws of motion			
linear momentum			
conservation of linear momentum			
work done			
kinetic energy			
gravitational potential energy			
power			

Recall

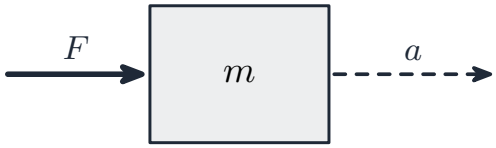
In **Part 1** you met forces, equilibrium, weight, friction, and the suvat equations. Part 2 adds **Newton's second law**, **momentum**, and **work, energy and power**.

New ideas

■ 1 Newton's second law

Newton's laws of motion connect force and acceleration. The key one is: resultant force = mass × acceleration,

$$F = ma.$$



$$F = ma$$

Worked example. A resultant force of 12 N acts on a 4 kg mass: $a = \dfrac{F}{m} = \dfrac{12}{4} = 3$ m s^{-2}.

Micro-check. A 6 N resultant force acts on a 2 kg mass. Find the acceleration. [1]

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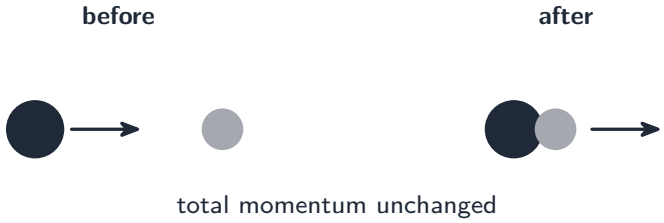
2 Momentum

The **linear momentum** of a body is mass × velocity (a vector). In a collision with no outside force, the total momentum is unchanged – the **conservation of linear momentum**:

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2.$$



Worked example. A 2 kg body at 3 m s^{-1} hits a stationary 1 kg body and they stick: $2(3) = 3v$, so $v = 2$ m s^{-1}.

Micro-check. Find the momentum of a 5 kg body moving at 4 m s^{-1}. [1]

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3 Work, energy and power

- **work done** by a force is force × distance moved: $W = Fd$ (in joules);
- **kinetic energy** $= \frac{1}{2}mv^2$; **gravitational potential energy** $= mgh$;
- **power** is the rate of doing work; for a driving force, $P = Fv$.

Worked example. A car engine works at 12 kW while moving at 20 m s^{-1}: driving force $F = \dfrac{P}{v} = \dfrac{12000}{20} = 600$ N.

Micro-check. Find the kinetic energy of a 2 kg body moving at 3 m s^{-1}. [1]

Watch out: $F = ma$ uses the *resultant* force. In a collision with no outside force, *momentum* (mv) is conserved: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$. Power for a driving force is $P = Fv$.

Practice

4.1 A resultant force of 20 N acts on a 5 kg mass. Find the acceleration. [2]

4.2 Find the momentum of a 1500 kg car moving at 12 m s^{-1}. [2]

4.3 A 3 kg body at 4 m s^{-1} hits a stationary 1 kg body and they stick together. Find their common speed. [2]

4.4 Find the kinetic energy of a 4 kg body moving at 5 m s^{-1}. [2]

4.5 A force pulls a load at 8 m s^{-1} with a driving force of 50 N. Find the power ($P = Fv$). [2]

4.6 Challenge. A 2 kg trolley moving at 5 m s^{-1} collides with a stationary 3 kg trolley and they stick together. Find their common speed, and the kinetic energy lost in the collision. [3]