A Level Physics Knowledge Organiser

Laws of motion and momentum

7

1. Newton's first and third laws of motion

Newton's first law of motion	A body will remain at rest or continue to move with constant velocity unless acted upon by a resultant force.
Newton's third law of motion	When two objects interact, each exerts an equal but opposite force on the other during the interaction.
Velocity	A vector quantity equal to the rate of change of displacement.
Zero gravity	The state or condition in which there is no apparent force of gravity acting on a body, either because the force is locally weak, or because both the body and its surroundings are freely and equally accelerating under the force.
Constant velocity	Motion in which the change in displacement per unit time stays the same.
Force	A push or pull on an object, measured in newtons, N.
Mass	Amount of matter, a base quantity measured in kilograms, kg.
Weight	The gravitational force on an object, measured in newtons, N.
Acceleration	The rate of change of velocity, a vector quantity.
Electrostatic force	The electrostatic force is also known as the Coulomb force or Coulomb interaction. It's the attractive or repulsive force between two electrically charged objects.
Magnetic force	Magnetic force**,** attraction or repulsion that arises between electrically charged particles because of their motion. Electric forces exist among stationary electric charges; both electric and magnetic forces exist among moving electric charges. The magnetic force between two moving charges may be described as the effect exerted upon either charge by a magnetic field created by the other.
Gravitational force	Gravity**,** also called gravitation**,** in mechanics, the universal force of attraction acting between all matter. It is by far the weakest known force in nature and thus plays no role in determining the internal properties of everyday matter.
Electromagnetic force	The fundamental force associated with electric and magnetic fields. The electromagnetic force is carried by the photon and is responsible for atomic structure, chemical reactions, the attractive and repulsive forces associated with electrical charge and magnetism, and all other electromagnetic phenomena. Like gravity, the electromagnetic force has an infinite range and obeys the inverse-square law. The electromagnetic force is weaker than the strong nuclear force but stronger than the weak force and gravity.
Four fundamental forces	Gravitational, electromagnetic, strong nuclear and weak nuclear forces.
Weak nuclear force	One of the four fundamental forces in nature, responsible for inducing beta-decay within unstable nuclei.
Strong nuclear force	One of the four fundamental forces in nature, acting on hadrons and holding nuclei together.

Fundamental Force Particles

Force	Particles Experiencing	Force Carrier Particle	Range	Relative Strength*
Gravity acts between objects with mass	all particles with mass	graviton (not yet observed)	infinity	much weaker
Weak Force governs particle decay	quarks and leptons	W^+, W^-, Z^0 (W and Z)	short range	
Electromagnetism acts between electrically charged particles	electrically charged	γ (photon)	infinity	
Strong Force** binds quarks together	quarks and gluons	g (gluon)	short range	much stronger

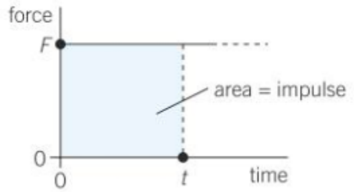
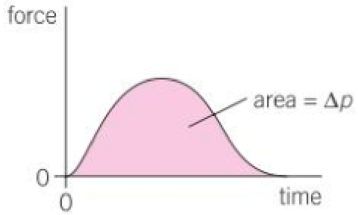
2. Linear momentum

Linear momentum	The product of the mass and velocity of a particle. momentum = mass x velocity p = m x v p – momentum (kg m s^{-1} or N s) m – mass (kg) v – velocity (m s^{-1})
Principle of conservation of momentum	Total momentum of a system remains the same before and after a collision.
Closed system	An isolated system that has no interaction with the surroundings.
Kinetic energy	The energy associated with an object as a result of its motion.
Open system	An open system is a system that has external interactions. Such interactions can take the form of information, energy, or material transfers into or out of the system boundary, depending on the discipline which defines the concept.
Elastic collision	Or perfect elastic collision is a collision in which there is no net loss in kinetic energy in the system as a result of the collision. Both momentum and kinetic energy are conserved quantities in elastic collisions. Total energy is conserved in elastic collisions.
Inelastic collision	A collision in which kinetic energy is transferred to other forms, e.g. heat. Both momentum and total energy are conserved quantities in inelastic collisions. Total kinetic energy is not conserved.
Linear air track	An air track is a scientific device used to study motion in a low friction environment.
Ticker timer	A device which 'prints' a dot on a length of tape at set intervals. 
Light gate	A light gate usually consists of an optical transmitter and receiver mounted in a frame with a gap between the two.

3. Newton's second law of motion

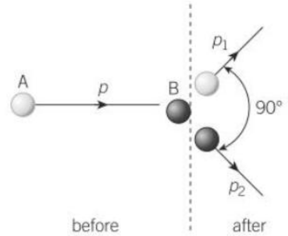
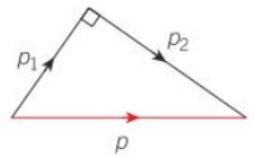
Newton's second law of motion	The rate of change of momentum of an object is directly proportional to the resultant force and takes place in the direction of the force. net force = rate of change of momentum F = Δp/Δt F – net (resultant) force (N) Δp – change of momentum (N s) Δt – time taken (s)
Delta Δ	Is a shorthand for *change in*.
Special case of Newton's second law	The mass m of the object remains constant during the period of acceleration F = mxa
Momentum of a closed system	▲ **Figure 3** *Two interacting objects* The net force acting on the objects in this closed system is zero. According to Newton's second law Δp/Δt = 0 The change in momentum Δp of both objects must be zero; therefore, the total momentum of the objects does not change. Momentum is always conserved.

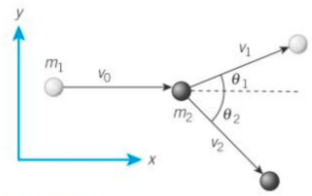
4. Impulse

Impulse	The area under a force-time graph – the product of force and the time for which the force acts. impulse of a force = force x time taken impulse (N s or kg m s^{-1})
Force-time graph Constant force	
Force-time graph Changing force	
Impulse of a force	According to Newton's second law of motion net force = rate of change of momentum F = Δp/Δt Rearranging this equation gives F x Δt = Δp The product of force and time is equal to the change in momentum. Impulse of a force = change in momentum

Photon	Subatomic particles that travel at the speed of light and have no mass. Photons have energy and momentum. p = h/λ p – momentum (kg m s^{-1}) h – Planck constant 6.63 x 10^{-34} J s λ – wavelength (m)

5. Collisions in two dimensions

Conservation of momentum	In collisions and interactions, linear momentum is conserved in all directions.
Adding momentum	Total final momentum is equal to the initial momentum since linear momentum must be conserved. The vector triangle for this example 

Resolving momentum	. The momentum in any direction must be conserved. x direction: total initial momentum = total final momentum y direction: total initial momentum = total final momentum