Chapter Five: Forces

Forces

-A force is a push or a pull that is applied from one object to another

-Contact forces need physical contact, whereas noncontact forces can act at a distance

Contact forces	Noncontact forces
Friction Tension Normal push or pull Air resistance	Magnetic force Gravitational force Electrostatic force

-A scalar quantity is one where only the size (magnitude) matters, whereas for a vector quantity, both size (magnitude) and direction are taken into account

Scalar	Vector
Distance Speed Time Mass Temperature Pressure Energy Power Current Potential difference Resistance	Displacement Velocity Acceleration Force Weight Moments

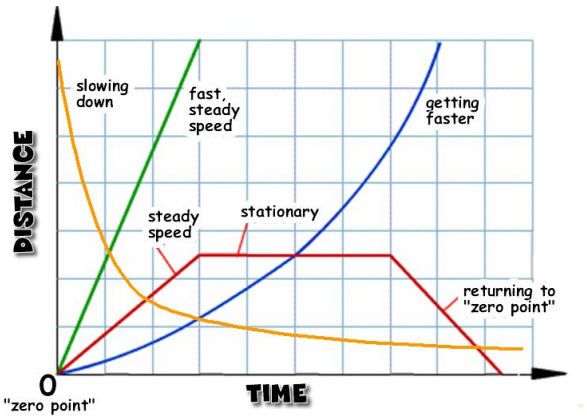
Motion

-Speed is a measure of how quickly something is travelling, it only takes into account the magnitude (scalar)

-Velocity is a measure of how quickly something is travelling, but the direction of travel is also taken into account (vector)

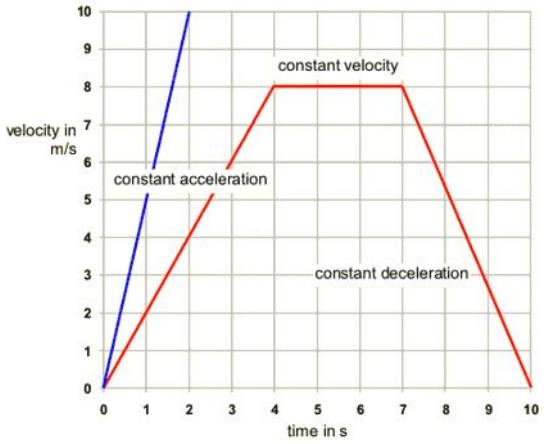
-On a distance time graph distance goes on the Y axis and time on the X axis, the graph features represent:

- -A flat horizontal line means the object is stationary
- -A straight diagonal line represents a constant speed away from the start point, the steeper the line, the greater the speed
- -A curved line represents an acceleration
- -The gradient of the line is equal to the speed



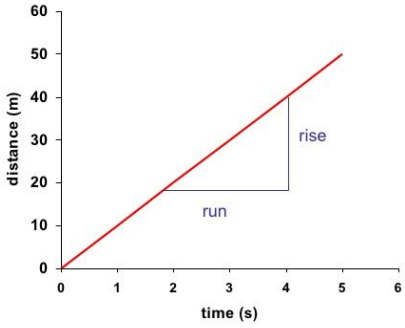
-On a velocity time graph velocity goes on the Y axis and time on the X axis, the graph features represent:

- -A flat horizontal line means the object is travelling at a steady velocity
- -A straight diagonal line represents an acceleration, the steeper the line, the greater the acceleration
- -A curved line represents an increasing acceleration
- -The gradient of the line is equal to the speed
- -The area underneath the graph is equal to the distance travelled by the object



-To find the gradient of a line, we use the rise / run:

The gradient of a distance-time graph = velocity



$$\text{gradient} = \frac{\text{rise}}{\text{run}} = \frac{20\text{m}}{2\text{s}} = 10$$

Velocity = 10 m/s

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-To find the gradient of a curved line (increasing acceleration) you can draw a tangent onto the curve

Gravity

-Gravity is a downwards pull towards the centre of a mass

-Gravitational field strength differs on different planets, being affected by the mass of the planet and the distance between the two objects

-The mass of an object is constant on any planet, however the weight (a force and vector) will vary due to the gravitational field strength of the planet

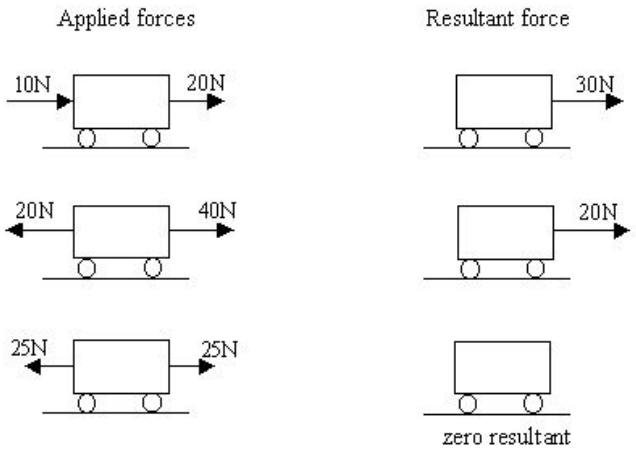
W = mg

Weight = mass x gravitational field strength

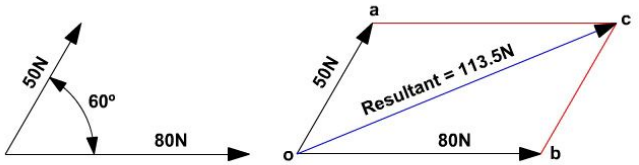
Newton's Laws

-Newton's first law states that if the resultant force on a object is zero, the object will either be at rest or a constant velocity

-The resultant force is the difference between two unbalanced forces



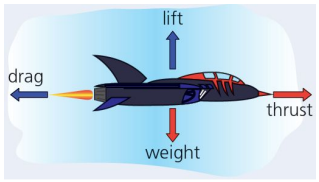
-A resultant force can be found by either using pythagoras theorem, or a parallelogram of forces (both need to be drawn to scale):

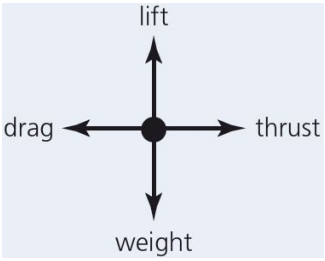


Parallelogram of Forces

-The terminal velocity of an object will be the maximum velocity that it can reach, this is the point where the resistive forces are equal and opposite to the movement forces, this is often seen with a falling object / a moving object

-A free body force diagram shows all of the forces acting on an object:



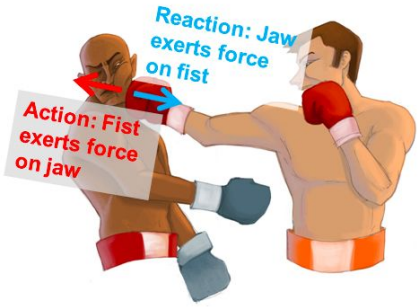


-Newton's second law states that force is equal to mass x acceleration (acceleration is the rate of change of velocity)

F = ma

Force = mass x acceleration

-Newton's third law states that when two forces interact, they exert a force which is equal and opposite on each other



-Inertia is the resistance of an object to change its velocity, either from moving to not moving, or not moving to moving

Moments

-A moment is the turning effect of a force measured in Nm

M = f x d

Moment = mass x distance from pivot

-The further the distance from the pivot, the less force needs to be applied to generate the same turning force, this is how levers work

-For an object to be balanced around a pivot, the clockwise and anticlockwise moment have to be equal and opposite

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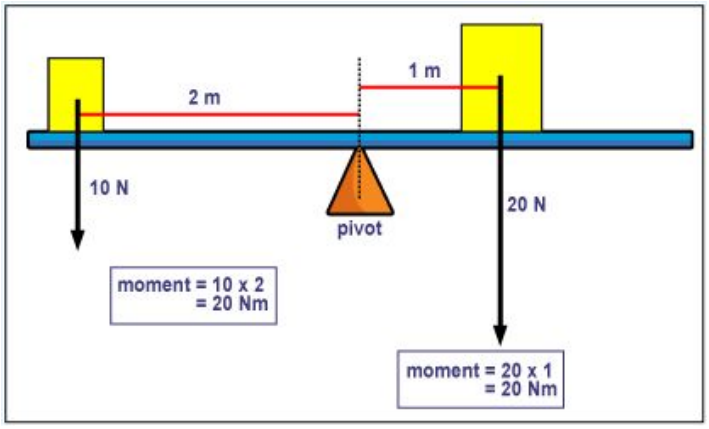


Momentum

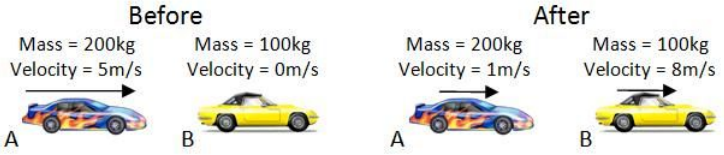
-Momentum is mass in motion, it is the impetus gained by a moving object, is it measured in kgm/s

p = mv

Momentum = mass x velocity

-Momentum is affected by both mass and velocity

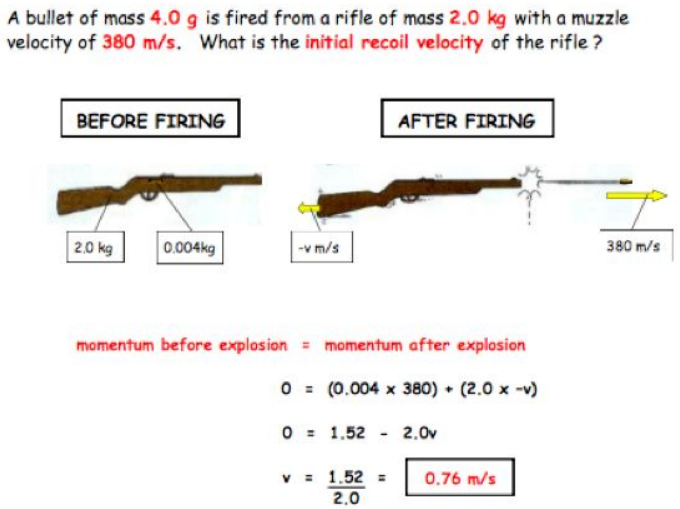
-Momentum is always conserved, meaning that the momentum before a collision will be equal to the momentum after a collision



Momentum Before = Momentum After

Momentum of Car A Before + Momentum of Car B Before	=	Momentum of Car A After + Momentum of B Car After
(Mass A x Velocity A) + (Mass B x Velocity B)	=	(Mass A x Velocity A) + (Mass B x Velocity B)
(200 x 5) + (300 x 0)	=	(200 x 1) + (100 x 8)
(1000) + (0)	=	(200) + (800)
1000 kg m/s	=	1000 kg m/s

-The conservation of momentum is also true for explosions, however, where the momentum before a collision is equal to the momentum after a collision, for an explosion, the momentum of the two objects are equal but opposite (one will be positive and one will be negative as momentum is a vector quantity)



Car safety

-Car safety features are designed in order to increase the time it takes the car to stop / reduce the force by decreasing the change in momentum

$$\text{force} = \frac{\text{momentum change}}{\text{time taken for the change}}$$

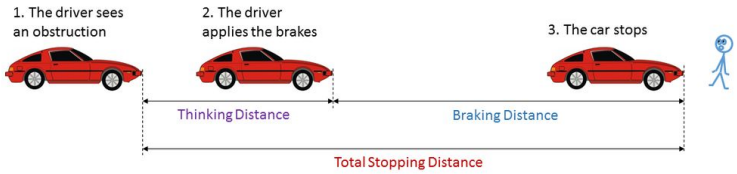
Feature	Explanation
Seat belts	The seat belt stops the person from carrying on forward with the car, it stops the distance they move forward reducing the impact force, whilst spreading out the force across the chest be being diagonal
Air bags	Decreases the distance a person will travel, spreads out the impact force and stops the person slower than if they hit a solid object
Crumple zones	Absorb kinetic energy from the impact by taking more time for the car to stop instead of coming to an immediate stop, reducing impact force
Side impact bars	Strengthens the structure of the car for an impact, meaning the structure will not give way
Child seats	Gives the child more protection and a better fitting seat belt in case of an impact

-The stopping distance of a car is the sum of the thinking and the stopping distance:

-Thinking distance is the time between seeing a hazard and applying the brakes
-Braking distance is the time between applying the brakes and the car coming to a stop

-These can be affected by a number of factors:

Thinking	Braking
Age Alcohol Drugs Distractions	Weather conditions Tyre tread depth Conditions of brakes Mass of car Type of road surface



Pressure

-Pressure is the force of particles colliding with a unit area of a container measured in pascals (Pa)

$$P = F / A$$

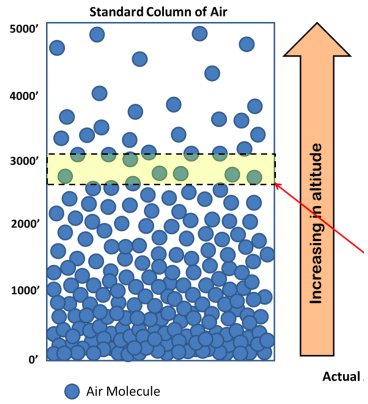
Pressure = force / area

-In a liquid, there deeper the particles, the greater the pressure, due to the other particles exerting the force of weight down on them

$$P = h \rho g$$

Pressure = height x density x gravity

-For an object to float, the upthrust caused by the water must be equal and opposite to the weight of the object
-Objects less dense than water will float, objects more dense than water will sink
-Atmospheric pressure is the force per unit area produced by the weight of the particles of air
-At higher altitudes, pressure is less as there is a lesser weight of particles (less particles are present)
-A difference in pressures will cause a force, this will be in the direction of the area of higher pressure to the area of lower pressure



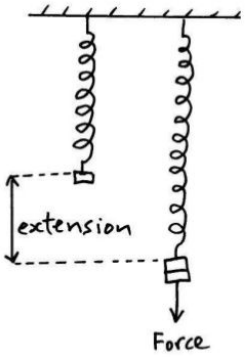
Hooke's Law

-Hooke's law states that the extension of a spring will be directly proportional to the force applied, it is measure in N/m

F=ke

Force = spring constant x extension

-The extension is the difference between the original and the stretched length of the spring



-The limit of proportionality is the point at which the force and extension are no longer directly proportional, the behaviour up until this point is known as elastic, after this it is inelastic
-After this point the spring will not return to its original length, this is known as permanent deformation