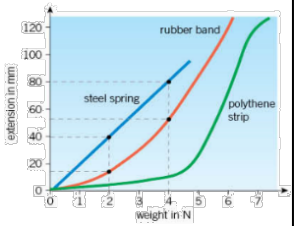
Forces Knowledge Organiser

Work done and energy transfer

- **Work** is done on an object when a force makes the object move.
- Energy transferred = work done
- $\underset{(joules)}{Work\ done} = \underset{(newtons)}{force} \times \underset{(metres)}{distance\ moved\ in\ the\ direction\ of\ the\ force}$

Forces and elasticity



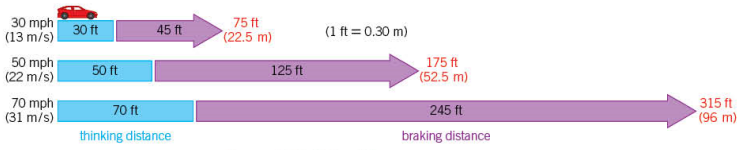
- An object is **elastic** if it returns to its original shape after removing the force deforming it.
- Hooke's law states that the extension of a spring is directly proportional to the force applied to it, as long as the limit of proportionality is not exceeded. This relationship is linear and the extension depends on the force applied and the **spring constant** of the spring, $F = ke$.
- Beyond the limit of proportionality, the extension of a spring is no longer proportional to the applied force. The relationship becomes non-linear.
- A force that stretches (or compresses) a spring does work and elastic potential energy is stored in the spring. The elastic potential energy stored depends on the spring constant of the spring and how much it is extended, $E_e = {}^1/_2\, ke^2$

Momentum

- **Momentum** is defined as mass x velocity, and has both size and direction.
- The momentum of a moving object is $\rho = mv$, The unit of momentum is kg m/s.
- The law of **conservation of momentum** states that the total momentum before an event is the same as the total momentum after the event provided there are no external forces acting.
- When vehicles collide, the force of the impact depends on mass, change of velocity, and the length of the impact time,
- The longer the impact time, the more the impact force is reduced. The shorter the impact time, the greater the impact force.
- When two objects hit each other it is called a **collision**, the objects:
  - exert equal and opposite forces on each other
  - combined total momentum is unchanged.
- When two objects push each other apart it is called an **explosion**, the objects move
  - with different speeds if they have unequal masses
  - with equal and opposite momentum, so their total momentum is zero

Forces and braking

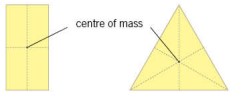
- Friction and air resistance oppose the driving force of a vehicle.
- The **stopping distance** of a vehicle depends on the **thinking distance** and the **braking distance**.



- High speed, poor weather conditions, and poor vehicle maintenance all increase the braking distance. Poor **reaction time** (due to tiredness, alcohol, drugs, or using a mobile phone) and high speed both increase the thinking distance.
- Cycle helmets and cushioned surfaces (e.g., in playgrounds) reduce impact forces by increasing the impact time.
- Seat belts and air bags spread the force across the chest and increase the impact time.
- Side impact bars and crumple zones give way in an impact, and so increase the impact time.
- Conservation of momentum can be used to find the speed of a car before an impact.

Mass and weight

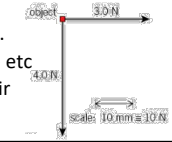
- **Weight** is the force acting on the object due to gravity.
- **Mass** is the amount of matter in an object
- $W = m \times g$, gravity on Earth = 10 N/Kg.
- The **centre of mass** of an object is the point where its mass can be thought of as being concentrated.



Speed, velocity and acceleration

- The **speed** of an object is: $v = \frac{s}{t}$
- The speed equation v=s/t can be rearranged to give: $s = vt$ or $t = \frac{s}{v}$
- **Velocity** is speed in a given direction.
- The **acceleration** of an object is $a = \frac{\Delta v}{t}$
- **Deceleration** is the change of velocity per second when an object slows down.

Vectors and scalars



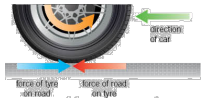
- A **vector** has magnitude and direction i.e. velocity, displacement, force etc.
- A **scalar** quantity has magnitude but no direction i.e. speed, distance, time etc
- Vectors can be represented by arrows in vector diagrams, which show their magnitude (length of arrow) and direction.

Resultant forces

- The **resultant force** is a single force that has the same effect as all the forces acting on an object.
- The resultant force is the sum of the forces acting in the same direction minus the forces acting in the opposite direction.
- When forces are **balanced** - the resultant force is zero.
- When forces are **unbalanced** - the resultant force is non-zero.

Force interactions

- **Forces** can change the shape, speed or direction of an object. The unit of force is the **newton** (N).
- A **contact force** is a force that acts on objects only when the objects touch each other.
- Gravity, static and magnetism are **non-contact forces**
- Forces always arise in **interaction pairs**, when objects interact, they always exert equal and opposite forces on each other.

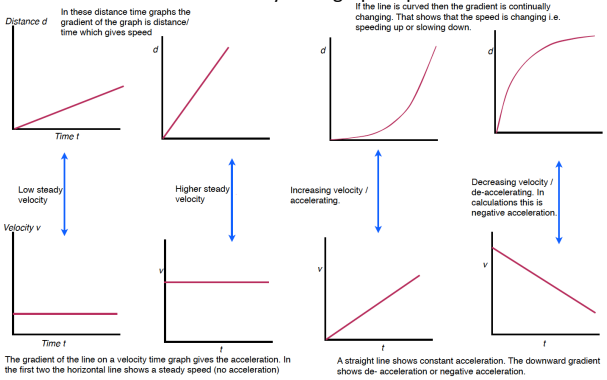


Newton's Laws of motion

- Newton's first law states that an object will remain at rest or at constant velocity unless acted upon by a resultant force.
- The **inertia** of an object is its tendency to stay at rest or in uniform motion.
- Newton's second law states that the resultant force is proportional to product of the mass and acceleration, $F = ma$.
- The greater the resultant force on an object, the greater its acceleration.
- The greater the mass of an object, the smaller its acceleration for a given force.
- Newton's Third Law states that when two objects interact, the forces they exert on each other are equal and opposite.

Motion graphs

- The **distance-time graph** for any object that is:
  - stationary, is a horizontal line
  - moving at constant speed, is a straight line that slopes upwards.
- The gradient of a distance-time graph for an object represents the speed.
- The **velocity-time graph** for any object that is:
  - moving at constant speed, is a horizontal line
  - accelerating, is a straight line that slopes upwards.
  - decelerating, is a straight line that slopes downwards.
- The gradient of the line on a velocity-time graph represents acceleration.
- The area under the line on a velocity-time graph represents distance travelled



Equations

$WD = Fs$ $\quad v = \frac{s}{t}$

$W = mg$ $\quad a = \frac{\Delta v}{t}$

$F = ma$ $\quad F = \frac{m\Delta v}{\Delta t}$

$v^2 = u^2 + 2as$ $\quad \rho = mv$

$E_e = {}^1/_2\, ke^2$ $\quad F = ke$

W = Weight (N)
F = Force (N)
WD = Work done (J)
g = gravitational field strength (N/Kg)
v = final velocity (m/s)
u = initial velocity (m/s)
s = displacement (m)
m = mass (Kg)
ρ = momentum (Kg m/s)
a = acceleration (m/s^2)
E_e = elastic potential energy (J)
e = extension (m)
k = spring constant (N/m)
t = time (s)

Key terms

Acceleration
Centre of mass
Collision
Conservation of momentum
Contact force
Deceleration
Distance-time graph
Elastic
Explosion
Inertia
Interaction pair
Mass
Momentum
Non-contact force
Reaction time
Resultant force
Scalar
Speed
Spring constant
Stopping distance
Vector
Velocity
Velocity-time graph
Weight
Work

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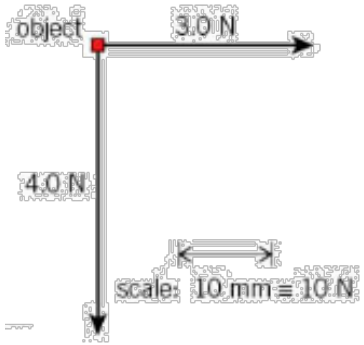

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Y9 Forces Knowledge Organiser

Resultant forces

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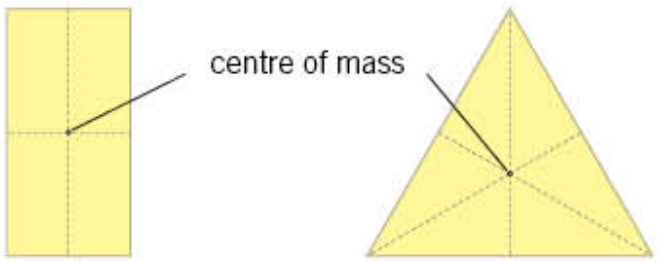

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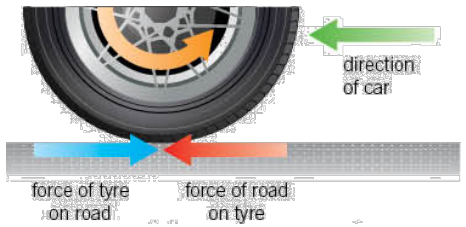

Key terms

Centre of mass
Contact force
Interaction pair
Mass
Non-contact force
Resultant force
Scalar
Speed
Vector
Velocity
Weight
Work

Speed, velocity and acceleration

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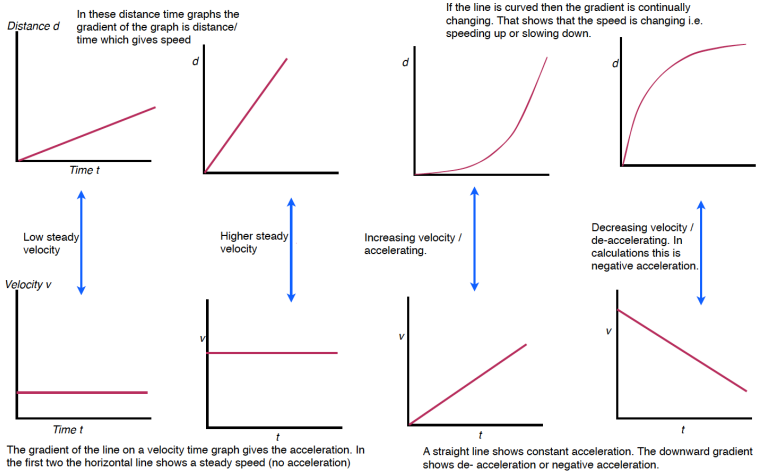
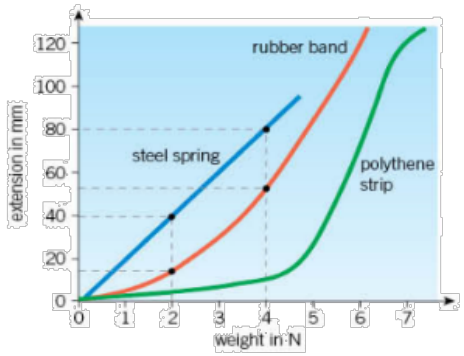


Forces and elasticity



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Y10 Forces Knowledge Organiser

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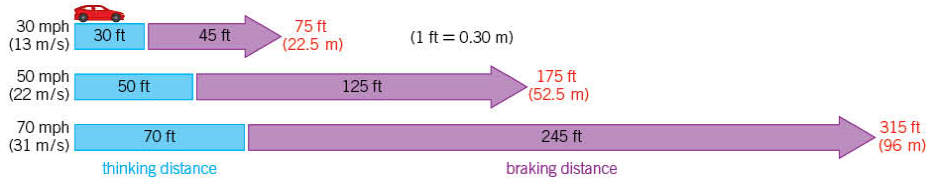

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Y11 Forces Knowledge Organiser

Equations

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