Physics 5: Forces

Section 1: Key terms

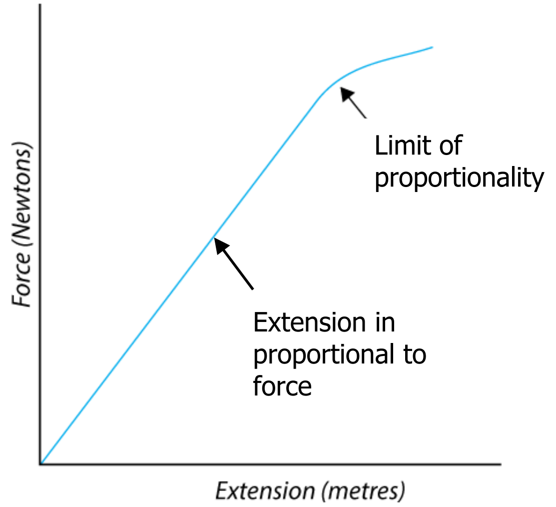
1 Scalar	A value with **magnitude (size) only,** e.g. **speed, distance.**
2 Vector	A value with **magnitude (size)** and **direction,** e.g. **all forces, displacement, velocity.**
3 Contact force	Force between objects that are **touching** e.g. friction, air resistance.
4 Non-contact force	Force between **separate objects** e.g. gravitational force, magnetic force.
5 Weight	The **force of gravity** acting **on an object's mass**. Measured using a **newtonmeter**.
6 Centre of mass	The **single point** at which the **object's weight appears to act**.
7 Resultant force	A resultant force is a **single force** that has the **same effect as all the forces** acting on an object.
8 Work done	Work is done when an **object is moved through a distance**. When work is done **against friction** there is a **temperature rise**.
9 Momentum (HT)	Moving objects with mass have momentum. Momentum is "**mass in motion**".
10 Conservation of momentum (HT)	In a closed system, the **total momentum before an event is equal to the total momentum after the event**.

Section 2: Equations to learn

	Equation	Symbol equation	Units
11	Weight = mass x gravitational field strength	W = m g	Weight – newtons (N) Mass – kilograms (kg) GFS – newtons per kilogram (N/kg)
12	Work done = force x distance	W = F s	Work done – joules (J) Force – newtons (N) Distance – metres (m)
13	Force = spring constant x extension	F = k e	Force – newtons (N) Spring constant – newtons per metre (N/m) Extension – metres (m)
14	Distance = speed x time	s = v t	Distance – metres (m) Speed – metres per second (m/s) Time – seconds (s)
15	Acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$	$a = \frac{\Delta v}{t}$	Acceleration = metres per second squared (m/s^2) Velocity = metres per second (m/s) Time = seconds (s)
26	Resultant force = mass x acceleration	F = m a	Force – newtons (N) Mass – kilograms (kg) Acceleration = metres per second squared (m/s^2)
17 (HT)	Momentum = mass x velocity	M = m v	Momentum – kilograms metres per second (kg m/s) Mass – kilograms (kg) Velocity = metres per second (m/s)

Section 3: Elasticity

18 Elastic deformation	Occurs when a **spring is stretched** and can then **return to its original length.**
19 Inelastic deformation	Occurs when a **spring is stretched** and its **length is permanently altered.**
20 Limit of proportionality	The **length** a spring can be **stretched before it no longer is able to return to its original length**. Beyond the limit of proportionality, a force-extension graph is curved.



21 Force-extension graph

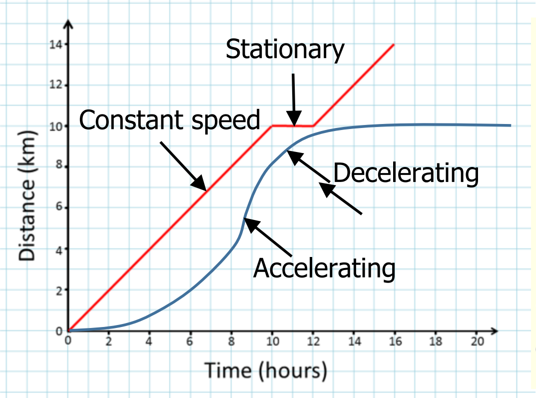
Section 4: Forces and Braking

21 Stopping distance	The stopping distance of a vehicle is the **sum** of the **distance the vehicle travels** during the driver's reaction time (**thinking distance**) and the distance it travels under the braking force (**braking distance**).
22 Thinking distance	The **distance a vehicle travels** while a driver is **reacting.**
23 Reaction time	The **time it takes for a driver to react**, typically **0.2-0.9s**. Affected by **tiredness**, **drugs**, **alcohol** and **distractions.**
24 Braking distance	The **distance a vehicle travels under braking**. Affected by **weather conditions** (e.g. rain or ice) and the **conditions of the brakes** and **tyres** of a vehicle.
25 Braking force	When the brakes are pressed, **work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle** and the **temperature of the brakes increases**. The **greater the speed** of a vehicle, the **greater the force** needed to stop the vehicle. **Large declarations** may lead to **loss of control** or **overheating** of the brakes.

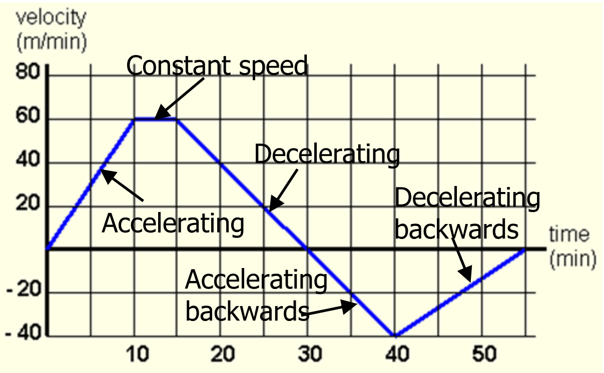
Section 5a: Motion

25 Displacement	The **distance** an object moves and the **direction** in which it occurs. A **vector** quantity.
26 Velocity	The **speed** of an object in a **particular direction**.
27 Acceleration	The change of an object's speed in a certain amount of time. If an object is **falling near the surface** of the Earth its **acceleration will be 9.8m/s^2**.
28 Terminal velocity	The **maximum speed** of a moving object. Occurs when the **force moving** an object (e.g. gravity) is **balanced by frictional forces** (e.g. air resistance).
29 Circular motion (HT)	An object **moving in a circle** has **constant speed but changing velocity**. This is because the direction in which the object is moving is constantly changing, and velocity is a vector quantity that measures direction and speed.

30 Distance-time graph	31 Velocity-time graph
Constant speed - straight line	Constant speed - horizontal line
Accelerating - curved line upwards	Accelerating - straight line with velocity increasing
Decelerating - curved line going towards horizontal	Decelerating - straight line with velocity decreasing
Stationary - horizontal line	Stationary - horizontal line on x-axis (velocity = 0)
	Moving backwards - below x-axis
Gradient of line can be calculated to give speed	Gradient of line can be calculated to give acceleration or deceleration



32 Distance-time graph



33 Velocity-time graph

Section 5b: Typical Values of Speed

32 Walking	1.5 m/s
33 Running	3 m/s
34 Cycling	6 m/s
35 Sound in air	330 m/s

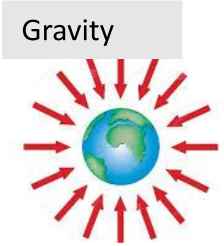
Section 6: Newton's Laws

36 Newton's First Law	The **velocity** of an object will **only change if a resultant force is acting** on the object. If there is **no resultant force** the object will: - **Remain stationary** if it was not moving. - **Continue at a constant speed** if it was already moving.
37 Newton's Second Law	The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object, i.e. Force = mass x acceleration.
38 Newton's Third Law	Whenever **two objects interact**, the **forces** they exert on each other are **equal and opposite**.
39 Inertia (HT)	The **tendency** of objects to **continue in their state of rest** or of **uniform motion**.

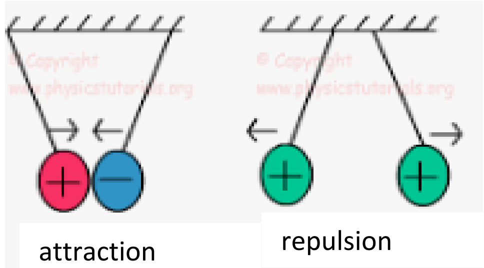
Section 7: identifying forces

None contact

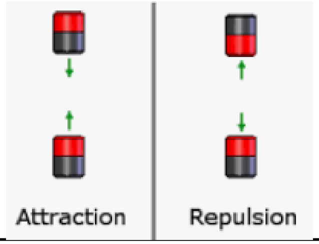
40. Gravitational



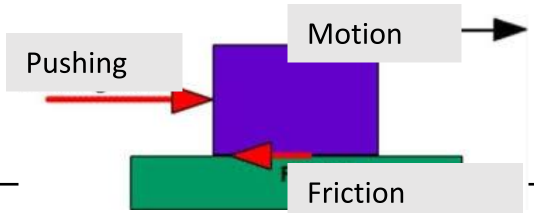
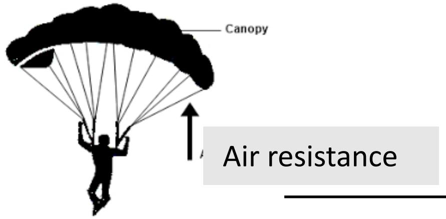
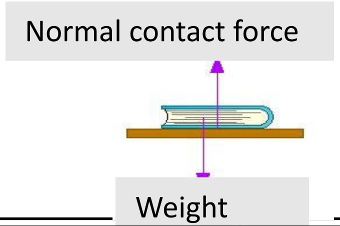
41. Electrostatic



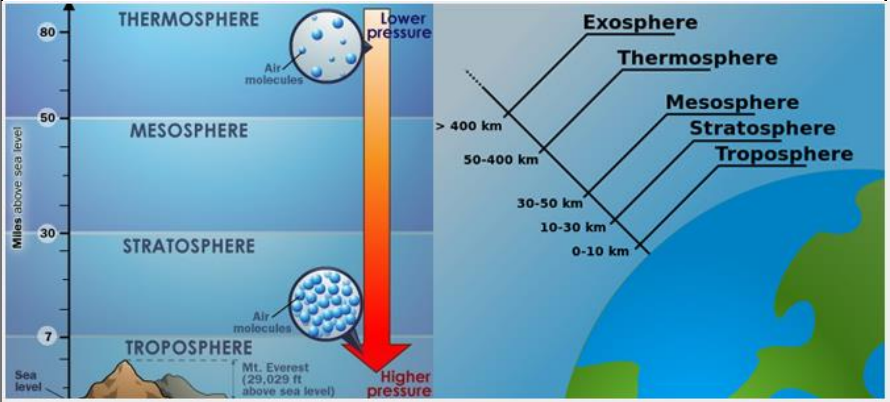
42. magnetic



Section 7: identifying forces

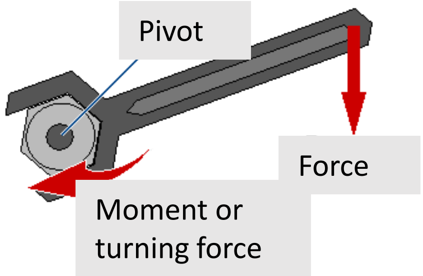
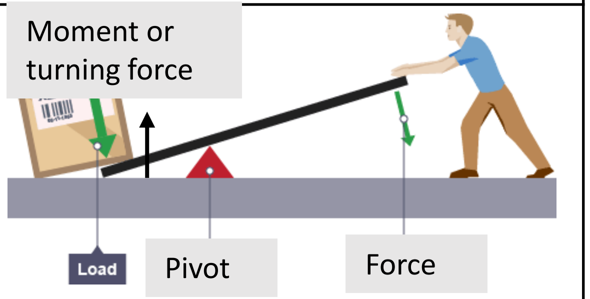
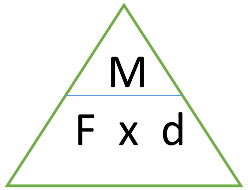
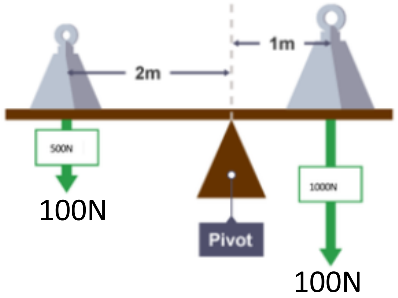
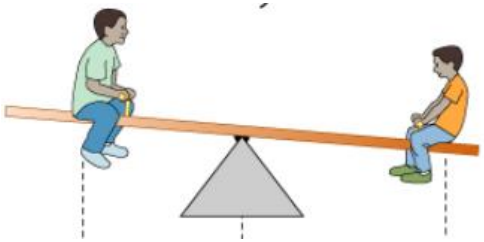
Contact	43. Friction	
	44. Air resistance	
	45. Tension	
	46. Normal contact	

Section 9: The Atmosphere and Pressure

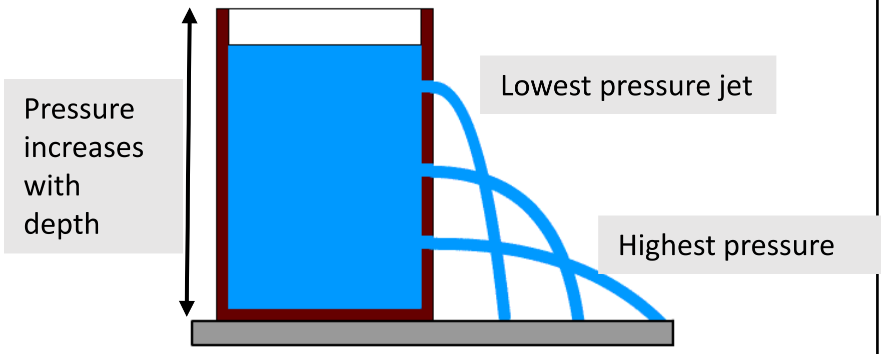


51. The further away from Earth's surface, the weaker gravity is. This means fewer air particles are held in upper layers. Causing lower air pressure.

Section 8: Moments

47. Definition of Moments	A force or a system of forces may cause an object to rotate. The turning effect of a force is called the moment of the force.
48. Examples of moments	 
49. Formula for moments	The size of the moment is defined by the equation: moment of a force = force × distance M = F x d  - moment of a force, M, in newton-metres, Nm - force, F, in newtons, N - distance, d, is the perpendicular distance from the pivot to the line of action of the force, in metres, m.
50. Balanced and unbalanced moments	If an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot. The object doesn't rotate.   IF they are unbalanced the object rotates in the direction of the larger moment.

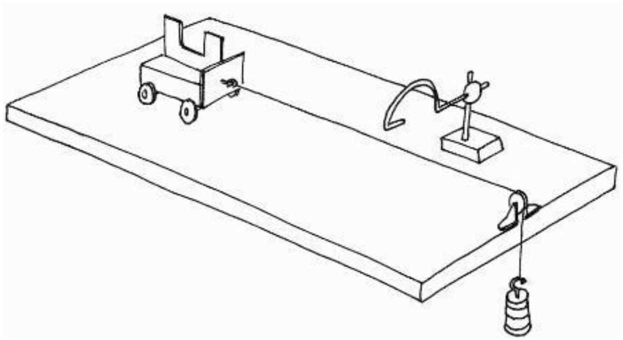
Section 10: Pressure

52. Effect of depth on water	 Water pressure is the result of the weight of all the water above pushing down on the water below. As you go deeper into a body of water, there is more water above, and therefore a greater weight pushing down.
53. Pressure formula	Pressure = $\frac{\text{Force}}{\text{Area}}$ $P = \frac{F}{A}$ P F x A Units of pressure are Pascals (Pa) Units of force are Newtons (N) Units of area are m^2 Pressure = height of the column x gravity x density of the liquid P = h x g x p P h x g x p Units of height are m Units of gravity areN/kg Units of density are kg/m^3

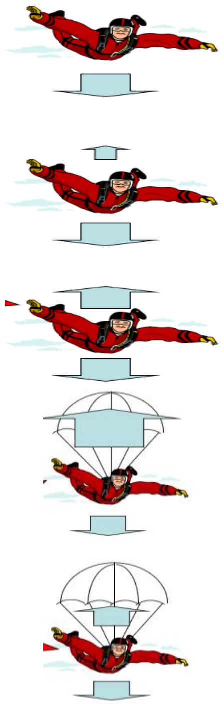
Section 11: Momentum

54. What is Momentum	- Momentum is how much an object want to keep moving. - Objects with more momentum are harder to stop. - The more **mass** and object has, the more momentum it has. - The greater the objects **velocity**, the more momentum it has. - Momentum is a vector quantity, it has both magnitude and direction. - Momentum = Mass x Velocity M = m x v - Units of momentum are kgm/s - Units of mass are kg - Units of velocity are m/s M m x v
55. Conservation of momentum	In a closed system the overall momentum will remain the same before and after a collision or explosion. If the objects was stationary initially then the momentum is zero.
56. Changing momentum	External forces can cause a change in momentum. Force = $\frac{\text{change in momentum(mass x change in velocity)}}{\text{Time}}$ F= $\frac{m \times v}{t}$ - If an objects momentum is changed in a very short time, there will be a large force exhorted. A larger force will cause more damage and injury.
57. Safety in Collisions	By increasing the time over which the collision occurs, causing a fixed change in momentum, we can reduce the force, making the collision safer. Car Safety Features: - Crumple zones - Air bags - Seat belts

Section 12: Investigating how Force and Mass Affect Acceleration

58. Method	• Fit a double segment black card on to the trolley. • Clamp the light gate at a height which allows both segments of the card to interrupt the light beam when the trolley passes through the gate. • Measure the width of each segment with a ruler, and enter the values into the software. • Pass a piece of string with a mass hanging on one end over a pulley. • Attach the other end to the trolley so that, when the mass is released, it causes the trolley to accelerate. • Fix a 1 kg mass on the trolley . • Select the first mass on the hanger to be 100g (1N). • Pull the trolley back so that the mass is raised to just below the pulley. • Position the light gate so that it will detect the motion of the trolley soon after it has started moving. • Set the software to record data, then release the trolley. Observe the measurement for the acceleration of the trolley. • Repeat this measurement from the same starting position for the trolley several times. • Increase it to 200 g (2N). Release the trolley from the same starting point as before. • Repeat the above procedure for slotted masses of 300g (3N) , 400g (4N) and 500g (5N). • The data logger will calculate the acceleration of the trolley as the force applied to the trolley increases. • Record the results in a table. 

Section 13: Terminal velocity

59. Definition	The point at which an object falls at a constant speed due to the forces of weight and air resistance being balanced.	
60. Forces	1)At the start of his jump the **air resistance** is zero and the forces are **unbalanced** so he accelerates downwards, due to the resultant force. 2) As his speed increases his air resistance will increase, reducing the resultant force and rate of acceleration. 3) Eventually the **air resistance** will be big enough to **equal** the skydiver's **weigh**t. At this point the forces are **balanced** so his speed becomes **constant** - this is called TERMINAL VELOCITY 4) When he opens his parachute the **air resistance** suddenly **increase**,causing a resultant force upwards, causing him to **decelerate**. 5) Because he is slowing down **his air resistance** will **decrease** again until it **balances** his **weight**. The skydiver has now reached a new, **lower terminal velocity**.	

61. Velocity time graph