

P5 Moments, levers and gears

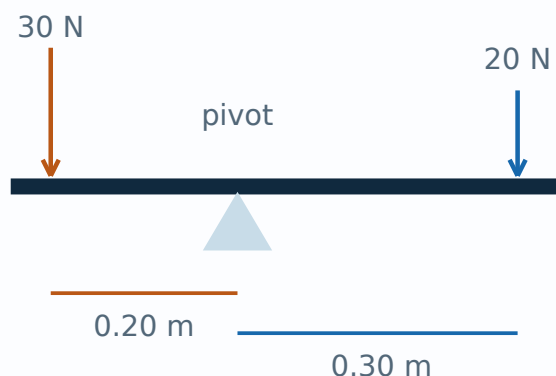
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Use alongside the shared topic notes. Foundation + Higher content.

Calculate a turning effect

$$M = F d$$

Moment M is in N m . Force F is in N . Distance d is the **perpendicular** distance in metres from the pivot to the force's line of action.



A balanced object has equal total clockwise and anticlockwise moments. Here $30 \times 0.20 = 20 \times 0.30 = 6 \text{ N m}$.

Use a lever



Longer effort arm: less force needed

The effort moves through a greater distance

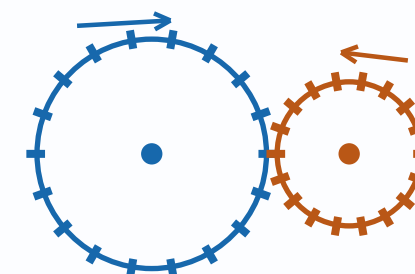
A lever transmits the turning effect of a force. Moving the effort farther from the pivot increases its moment for the same force.

A smaller effort can balance a larger load when the effort's perpendicular distance is larger.

Example: a 120 N load acts 0.10 m from a pivot. At 0.60 m on the other side, an effort of 20 N balances it.

Take care: the distance along a tilted lever is not always the perpendicular distance required.

Transmit rotation with gears



larger gear

smaller gear

Meshed gears rotate in opposite directions

Teeth transfer force between meshed gears. Adjacent gears rotate in opposite directions.

A small driving gear turning a larger gear gives slower output rotation and a larger turning effect. Reversing this arrangement gives faster output with a smaller turning effect.

Gears and levers transfer energy; they do not create it. A greater force or moment comes with a change in distance moved or rotational speed.

P5 Fluid and atmospheric pressure

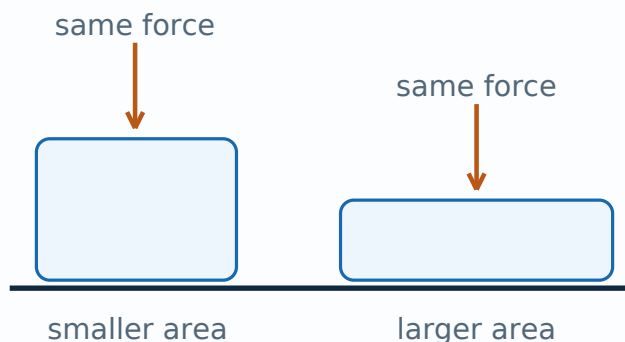
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Pressure is force per area

$$p = \frac{F}{A}$$

Pressure p is in pascals (Pa), force F in newtons (N), and area A in square metres (m^2). One pascal is one newton per square metre.



Pressure depends on force per unit area

For the same normal force, a smaller area gives a larger pressure. Convert area carefully: $1 \text{ cm}^2 = 10^{-4} \text{ m}^2$.

Liquids and gases are fluids

A fluid can flow: it may be a liquid or a gas. Fluid pressure causes a force **normal** to a surface, meaning at right angles to it.

Example: a fluid exerts a 240 N normal force on 0.060 m^2 .

$$p = \frac{240}{0.060}$$

Pressure = **4000 Pa**. Rearrange as $F = pA$ to calculate the normal force on a known area.

Pressure is a scalar; force has direction. Draw force arrows perpendicular to each surface, including curved surfaces.

Why air pressure falls



Air becomes less dense as altitude rises

Air molecules collide with surfaces and produce atmospheric pressure. Earth's atmosphere is thin compared with Earth's radius.

At higher altitude there is less air above the surface, so the weight of the air above is smaller. The atmosphere is also less dense.

Atmospheric pressure therefore decreases with increasing altitude. Do not say gravity becomes zero: the explanation is the smaller weight of air above.

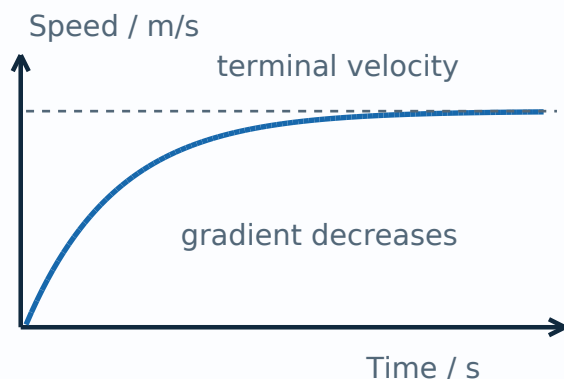
P5 Terminal velocity and stopping graphs

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Explain a terminal-speed curve

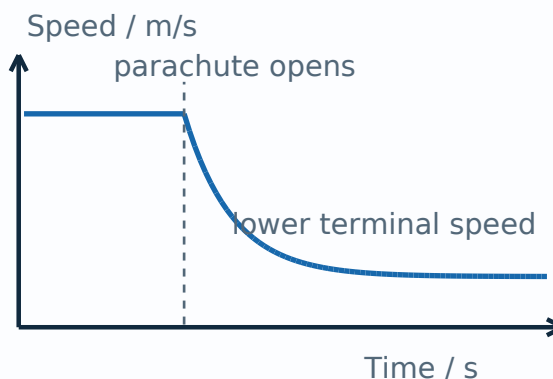


Just after release, weight exceeds drag, so the falling object accelerates. As speed rises, drag increases.

The resultant downward force gets smaller, so acceleration decreases: the speed-time curve becomes less steep.

At terminal velocity, drag balances weight. Resultant force and acceleration are zero, and speed is constant. Balanced forces do not mean the object has stopped.

Interpret a parachute graph

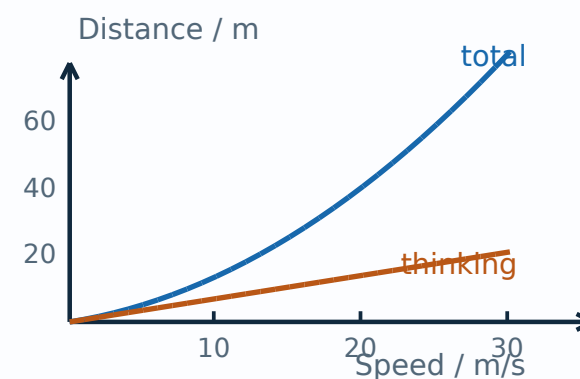


Opening a parachute increases drag. Initially drag exceeds weight, so the resultant force is upward and the falling person slows down.

As speed decreases, drag decreases. Eventually drag again balances weight and the person falls at a lower terminal velocity.

A downward-moving person can have an upward resultant force: the force changes the velocity; it need not point in the motion's direction.

Estimate stopping distances



Stopping distance = thinking distance + braking distance. Read the total at the stated speed; subtract one part from the total to find the other.

Use a graph's scale and units to estimate between plotted values. The illustrative model here gives about 41 m at 20 m/s.

At the same speed, compare vehicle curves directly. Wet roads, worn tyres, poor brakes and greater load can increase braking distance; tiredness can increase thinking distance.

P5 Liquid pressure and upthrust

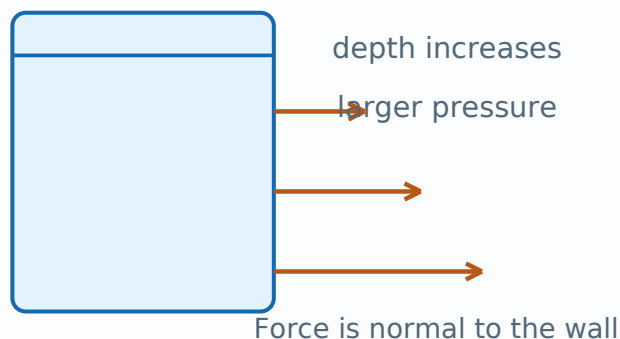
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Pressure grows with depth

$$p = h \rho g$$

h is depth in m, ρ is liquid density in kg/m^3 and g is gravitational field strength in N/kg . This gives pressure due to the liquid column in Pa.



Greater depth means a taller liquid column above; greater density means more mass in that column. Both increase the pressure.

Calculate pressure changes

Example: water has density 1000 kg/m^3 and $g = 9.8 \text{ N/kg}$. Find the increase in pressure from 2 m to 5 m depth.

$$\Delta p = \Delta h \rho g$$

$\Delta h = 3 \text{ m}$, so $\Delta p = 3 \times 1000 \times 9.8 = \mathbf{29\,400 \text{ Pa}}$.

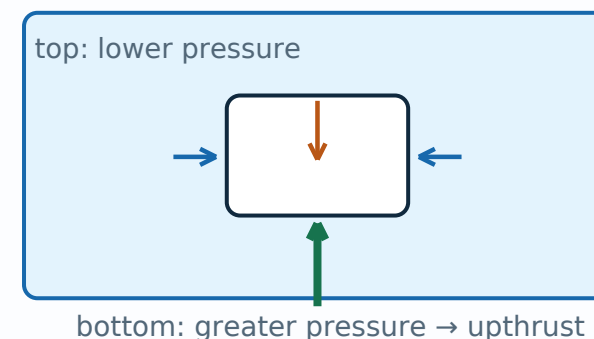
Use the change in depth for a pressure difference. The same atmospheric pressure acts at the surface and cancels in the comparison.

For total pressure at depth in an open liquid, add atmospheric pressure if the question asks for it.

Check: twice the depth gives twice the pressure due to the liquid, if density and g stay constant.

Explain floating and sinking

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Pressure is greater on the bottom surface than the top. This difference produces a resultant upward force called **upthrust**.

An object rises if upthrust exceeds weight and sinks if weight exceeds upthrust. It floats at rest when the forces balance.

For a freely floating object, the displaced liquid's weight equals the object's weight. Average density helps predict whether an object can float.

P5 Momentum calculations and safety

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Conserve total momentum

Shared foundation: momentum $p = mv$, measured in kg m/s. In a closed system, total momentum before equals total momentum after an event.



Before: $(2 \times 3) + (1 \times 0) = 6$ kg m/s. After the trolleys join: $3v = 6$, so $v = \mathbf{2 \text{ m/s}}$.

Choose a positive direction. A velocity in the opposite direction is negative. Include every object in the system.

Force changes momentum

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

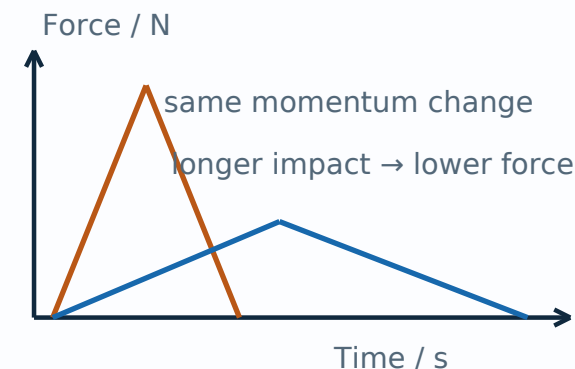
The average resultant force equals change in momentum divided by time. For constant mass, $\Delta v = \text{final velocity} - \text{initial velocity}$.

Example: a 0.15 kg ball changes from +20 m/s to -10 m/s in 0.050 s.

$\Delta v = -30$ m/s. $F = 0.15 \times (-30) \div 0.050 = \mathbf{-90 \text{ N}}$. The force is opposite the chosen positive direction.

A rebound can give a larger momentum change than stopping. Use signed velocities before calculating the change.

Explain safety features



For the same momentum change, increasing the stopping time reduces the average force.

Airbags, seat belts, crash mats, helmets and cushioned surfaces deform or stretch, increasing the time taken to stop.

Link the feature to time and then force:
longer stopping time → smaller rate of momentum change → smaller average force.

The sketch compares impacts with the same momentum change; it does not imply their peak forces are equal.