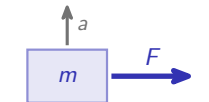


Motion, Forces & Energy

IGCSE Physics ■ Topic 1

IGCSE Physics



Motion, Forces & Energy

What we will cover

- 1 Measurement & motion
- 2 Mass, weight & density
- 3 Forces & moments
- 4 Momentum
- 5 Energy, work & power
- 6 Pressure



1 Measurement and motion

Measurement

Five SI base units used here:

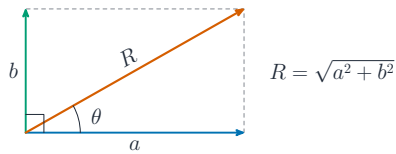
m	kg	s	A	K
length	mass	time	current	temperature

Measure **many** and divide: 100 pages → one thickness; 20 swings → one **period** 周期. Quote a unit; uncertainty $\approx$ half the smallest division.

Scalars and vectors

- **scalar** 标量 – size only (distance, speed, mass)
- **vector** 矢量 – size *and* direction (force, velocity)

At right angles, $R = \sqrt{a^2 + b^2}$.



Speed, velocity and acceleration

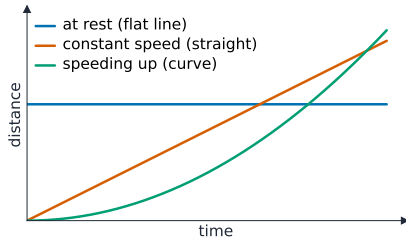
$$v = \frac{s}{t}, \quad a = \frac{\Delta v}{\Delta t}.$$

Speed is a scalar; **velocity** 速度 is speed in a direction.

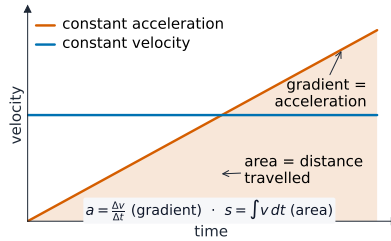
Car: 8 → 20 m/s in 4.0 s

$$a = \frac{20 - 8}{4.0} = 3.0 \text{ m/s}^2$$

Motion graphs



distance–time: gradient = speed

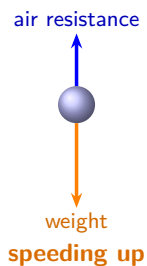


speed–time: gradient = a ; area = s

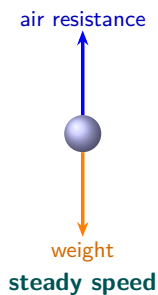
Never read one graph as if it were the other. A curve means the speed is changing.

Falling and terminal velocity

just released



terminal velocity



Near Earth, $g \approx 9.8 \text{ m/s}^2$ for every object.

- **weight** 重力 down; **air resistance** 空气阻力 up
- drag grows as the object speeds up

Terminal velocity 收尾速度:
drag = weight, resultant = 0,
speed is steady.

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Mass, weight and density

Mass, weight and density

- mass (kg) – amount of **matter** 物质, same everywhere
- weight (N) – gravity's pull, $W = mg$
- **density** 密度 $\rho = \frac{m}{V}$

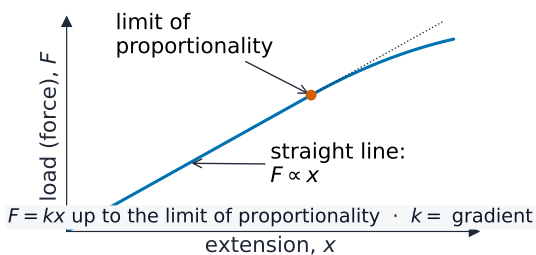
Floats if its density < the liquid's.

Stone 54 g, water 20 → 40 cm³

$$V = 20 \text{ cm}^3, \rho = \frac{54}{20} = 2.7 \text{ g/cm}^3$$

3 Forces and moments

Hooke's law

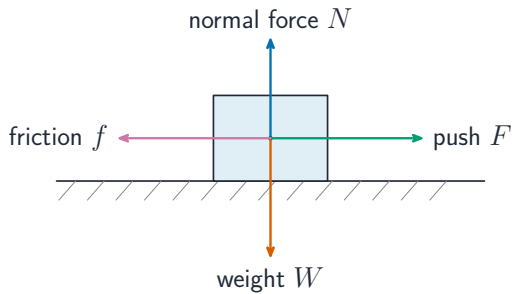


Extension 伸长量 is proportional to load up to the **limit of proportionality** 比例极限.

$$k = \frac{F}{x}.$$

A large **spring constant** 弹簧常数 k means a stiff spring.

Resultant force and $F = ma$



Resultant force 合力 zero $\Rightarrow$ rest or constant velocity.
Otherwise

$$F = ma.$$

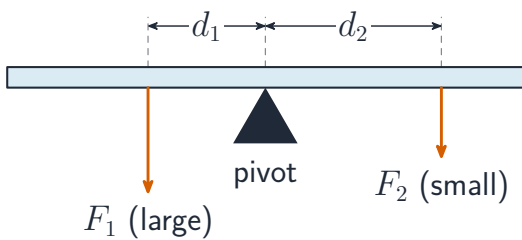
Friction 摩擦 opposes motion (or the tendency to move).

Car 1200 kg: 3000 – 600 N

$$a = \frac{2400}{1200} = 2.0 \text{ m/s}^2$$

Moments – the turning effect

balanced: $F_1 d_1 = F_2 d_2$



Moment 力矩 = force $\times$ perpendicular distance.

Balanced: total clockwise = total anticlockwise moment.

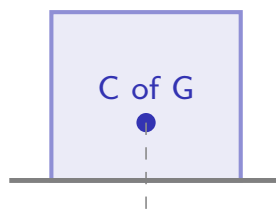
30 N at 0.20 m vs 20 N

$$d = \frac{30 \times 0.20}{20} = 0.30 \text{ m}$$

Centre of gravity and stability

The **centre of gravity** 重心 is where all the weight seems to act.

More **stable** with a **low** centre of gravity and a **wide** base. It tips when the C of G passes outside the base.



4 Momentum

Motion, Forces & Energy
└ Momentum

Momentum

Momentum 动量 $p = mv$ (a vector). Force is the change per unit time:

$$F = \frac{\Delta p}{\Delta t}.$$

Conservation 动量守恒: total momentum before = after (no outside force).

2.0 kg at 3.0 m/s hits a still
1.0 kg; they stick

$$v = \frac{2.0 \times 3.0}{3.0} = 2.0 \text{ m/s}$$

5 Energy, work and power

Energy stores and transfers

Energy is **stored** (**kinetic** 动能, gravitational, chemical, elastic, nuclear, internal) and **transferred** by forces, heating, electric current and waves.

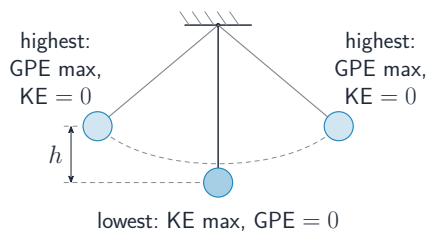
Conservation of energy 能量守恒定律: it changes store and path, but the total stays the same.

Energy resources

Most generators spin a turbine. Most traces go back to the **Sun** – exceptions: geothermal, nuclear, tidal.

- **fossil / nuclear** – not renewable; high output
- **wind / solar / hydro / biofuel** – renewable; often intermittent
- **solar cells** 太阳能电池 make electricity directly; solar panels heat water

Kinetic and potential energy



$$E_k = \frac{1}{2}mv^2, \quad \Delta E_p = mg\Delta h.$$

Conservation of energy 能量守恒定律:
a falling object turns E_p into E_k .

Drop from 1.8 m ($g = 10$)

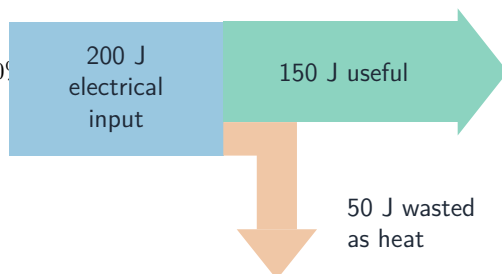
$$v = \sqrt{2g\Delta h} = 6.0 \text{ m/s}$$

Work, power and efficiency

$$W = Fd, \quad P = \frac{W}{t}, \quad \eta = \frac{\text{useful}}{\text{total}} \times 100\%$$

Motor: 200 J in, 150 J useful

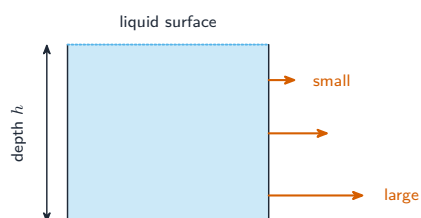
$$\eta = \frac{150}{200} \times 100\% = 75\%$$



Sankey diagram 桑基图: useful vs wasted

6 Pressure

Pressure



Pressure 压强 $p = \frac{F}{A}$ (Pa). A small area gives a large pressure. In a liquid it grows with depth: $\Delta p = \rho g \Delta h$.

2.0 m deep in water

$$\Delta p = 1000 \times 10 \times 2.0 = 2.0 \times 10^4 \text{ Pa}$$

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Recap

Motion, Forces & Energy

↳ Recap

Topic 1 – key takeaways

1 Motion

$v = s/t$, $a = \Delta v/\Delta t$; graphs

2 Forces

$F = ma$; moments balance; $W = mg$

3 Momentum

$p = mv$, conserved in collisions

4 Energy

$E_k = \frac{1}{2}mv^2$, $E_p = mgh$; conserved

Motion, Forces & Energy

↳ Recap

Check yourself

- 1 What does the area under a velocity–time graph give?
- 2 A 2 kg mass on the Moon – does its mass change?
- 3 Resultant force at terminal velocity?
- 4 Why is a knife sharp (small area)?



Answers 1. the distance 2. no (weight does) 3. zero 4. large pressure from a small area