IGCSE Physics

Revision Sheet · 考前速记

Learn these by heart before the exam. 考试前把这些内容背熟。

Motion, forces and energy

$v = \frac{s}{t}$ average speed = total distance ÷ total time 速率

$a = \frac{\Delta v}{\Delta t}$ unit m/s^2; negative value = deceleration 加速度

Graphs: distance-time gradient = speed; speed-time gradient = acceleration; area under speed-time = distance.

$\rho = \frac{m}{V}$ kg/m^3 or g/cm^3; an object floats when its density < density of the liquid 密度

$W = mg$ $g = 9.8$ N/kg on Earth (gravitational field strength) 重力

$F = ma$ resultant force; unit newton (N) 合力

Terminal velocity 终极速度: constant top speed when air resistance has grown to balance weight, so resultant force = 0

$k = \frac{F}{x}$ Hooke's law: extension ∝ force up to the limit of proportionality 弹簧常数

moment $= F \times d$ d = perpendicular distance from the pivot; unit N m 力矩

Principle of moments 力矩原理: in equilibrium, total clockwise moment = total anticlockwise moment about any point

Centre of gravity 重心: the point where all the weight of an object appears to act

$p = mv$ unit kg m/s; conserved in collisions when no external force acts 动量

$F\,\Delta t = \Delta(mv)$ impulse = change of momentum; crumple zones increase Δt to cut the force 冲量

$E_k = \frac{1}{2}mv^2$ 动能

$\Delta E_p = mg\,\Delta h$ 重力势能

$W = Fd$ work done = energy transferred; unit joule (J) 功

$P = \frac{W}{t} = \frac{E}{t}$ unit watt (W); 1 W = 1 J/s 功率

efficiency $= \frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$ 效率

$p = \frac{F}{A}$ unit pascal (Pa); small area ⇒ large pressure 压强

$\Delta p = \rho g \Delta h$ pressure difference in a liquid of density ρ at depth change Δh 液体压强

Scalar vs vector 标量与矢量: scalar has size only (speed, distance, energy, time); vector has size and direction (velocity, force, weight, acceleration, momentum)

Thermal physics

$c = \frac{\Delta E}{m\,\Delta\theta}$ energy per kg per °C; unit J/(kg °C) 比热容

Specific heat capacity 比热容: the energy needed to raise the temperature of 1 kg of a substance by 1 °C

$p_1V_1 = p_2V_2$ fixed mass of gas at constant temperature 玻意耳定律

Internal energy 内能: the total kinetic and potential energy of all the particles in an object; heating raises it

Evaporation vs boiling 蒸发与沸腾: evaporation happens at any temperature, only at the surface, and cools the liquid; boiling happens at one fixed temperature, throughout the liquid

Conduction 传导: energy passed on by particle vibrations (and free electrons in metals); how solids transfer heat

Convection 对流: hot fluid expands, becomes less dense and rises, setting up a circulating current; liquids and gases only

Radiation 辐射: energy carried by infrared waves; needs no particles, so it works through a vacuum

Dull black surfaces are the best absorbers AND best emitters of infrared; shiny white/silver are the worst.

Brownian motion: smoke particles jiggle randomly because fast, invisible air molecules hit them (evidence for moving molecules).

Gas pressure comes from molecules colliding with the walls; hotter gas means faster molecules, so more frequent and harder collisions.

Waves, light and sound

$v = f\lambda$ speed (m/s) = frequency (Hz) × wavelength (m) 波速

Transverse vs longitudinal 横波与纵波: transverse vibrates at right angles to travel (light, water waves); longitudinal vibrates along the direction of travel (sound), with compressions and rarefactions

$n = \frac{\sin i}{\sin r}$ light bends TOWARDS the normal entering a denser medium 折射率

$n = \frac{1}{\sin c}$ 临界角

Critical angle 临界角: the angle of incidence that gives an angle of refraction of 90°; beyond it, total internal reflection

Total internal reflection 全反射: all light reflects back inside the denser medium when the angle of incidence exceeds the critical angle; used in optical fibres

$M = \frac{h_i}{h_o}$ linear magnification = image height ÷ object height 放大率

Law of reflection: angle of incidence = angle of reflection; the image in a plane mirror is virtual, upright, same size, and as far behind the mirror as the object is in front.

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EM spectrum, long to short wavelength: radio, microwave, infrared, visible, ultraviolet, X-rays, gamma. All travel at 3.0×10^8 *m/s in a vacuum.*

Visible light by wavelength: red is longest, violet shortest (dispersion order red, orange, yellow, green, blue, indigo, violet).

Range of human hearing 人耳听觉范围: about 20 Hz to 20 000 Hz; above this is ultrasound

Sound needs a medium (no sound in a vacuum); speed of sound in air is about 330 to 350 m/s. Echo method: $v = \frac{2d}{t}$ *(the sound travels there and back).*

Electricity and magnetism

$Q = It$ charge (C) = current (A) × time (s) 电荷

$V = \frac{W}{Q}$ p.d. = energy transferred per unit charge; 1 V = 1 J/C 电压

E.m.f. 电动势: the electrical work done by a source (cell, generator) per unit of charge driven round the circuit; unit volt

$R = \frac{V}{I}$ unit ohm (Ω) 电阻

$P = VI = I^2R$ 电功率

$E = VIt$ 电能

$R_s = R_1 + R_2$ series: same current everywhere; p.d.s add up 串联电阻

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ parallel: same p.d. across each branch; currents add; combined resistance is LESS than the smallest branch 并联电阻

Resistance of a wire: $R \propto \frac{L}{A}$ *– doubling length doubles R; doubling cross-sectional area halves R.*

I-V graphs: fixed resistor = straight line through the origin; filament lamp = curve flattening (hotter filament, more resistance); diode conducts one way only.

$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ step-up has more secondary turns; for an ideal (100% efficient) transformer $V_pI_p = V_sI_s$ 变压器

Power is transmitted at high voltage so the current is small: less energy wasted as heat in the cables ($P_{loss} = I^2R$).

Electromagnetic induction 电磁感应: an e.m.f. is induced when a conductor cuts magnetic field lines, or the field through a circuit changes; faster cutting, more turns or a stronger magnet give a bigger e.m.f.

Motor effect: a current-carrying wire in a magnetic field feels a force (Fleming's left-hand rule: First finger Field, seCond finger Current, thuMb Motion).

Fuse and earth wire 保险丝与地线: the fuse melts if the current is too large (pick a rating just above normal current); the earth wire gives fault current a safe path so the case cannot become live

Switches and fuses go in the LIVE wire; double-insulated appliances need no earth wire.

Nuclear physics

Nuclide notation 核素表示法: ^A_ZX – A = nucleon (mass) number, Z = proton number; decay equations must balance both

Isotope 同位素: atoms of the same element with the same proton number but different nucleon numbers (different numbers of neutrons)

Half-life 半衰期: the time taken for half the nuclei of that isotope in any sample to decay (activity halves each half-life)

Alpha α*: helium nucleus (*^4_2He*), charge +2, stopped by paper or a few cm of air; most ionising.*

Beta β*: fast electron from the nucleus (a neutron becomes a proton), charge −1, stopped by a few mm of aluminium.*

Gamma γ*: electromagnetic wave, no charge or mass, reduced by thick lead or concrete; least ionising, most penetrating.*

Alpha and beta deflect opposite ways in electric and magnetic fields; gamma is not deflected.

Background radiation 本底辐射: always-present radiation from radon gas, rocks and buildings, cosmic rays, food, and medical sources; subtract it from measured count rates

Fission vs fusion 裂变与聚变: fission: a heavy nucleus (e.g. U-235) splits after absorbing a neutron, releasing energy and more neutrons (chain reaction); fusion: light nuclei join at extreme temperature and pressure, powering stars

Space physics

$v = \frac{2\pi r}{T}$ orbital speed; r = orbit radius, T = orbital period 轨道速度

Red-shift 红移: light from distant galaxies is stretched to longer wavelengths, showing the galaxies are moving away; the further away, the faster (evidence for the expanding Universe)

$H_0 = \frac{v}{d}$ Hubble's law; the age of the Universe is about $\frac{1}{H_0}$ ($d = \frac{v}{H_0}$) 哈勃常数

Evidence for the Big Bang 大爆炸的证据: red-shift of galaxies (everything moving apart) and the cosmic microwave background radiation (CMBR), the leftover radiation now stretched into microwaves

Life cycle of a star 恒星演化: nebula, protostar, main-sequence star; a Sun-like star then becomes red giant, planetary nebula, white dwarf; a massive star becomes red supergiant, supernova, then a neutron star or black hole

Light-year 光年: the DISTANCE light travels in one year (about 9.5×10^{15} m)

The Sun: a medium main-sequence star (one of billions in the Milky Way) powered by fusion of hydrogen into helium; planets orbit in ellipses, faster when closer.