# AP Physics 2

*Physics 2 questions usually offer three plausible starting equations, and choosing between them IS the physics. Every solution here opens by saying which principle applies and why it is legal in this situation, then computes.* 每题先说明所用原理及其适用条件，再进行计算。

## Fluids

**A block of density 600 kg/m$^3$ and volume 0.020 m$^3$ floats in water. What fraction is submerged, and what upward force must be applied to fully submerge it?**

0.60 submerged; 78 N to push it fully under.

*Floating means the buoyant force equals the weight, so ρ_water V_sub g = ρ_block V g. The g and the volumes give V_sub/V = 600/1000 = 0.60 – the submerged fraction is simply the density ratio, which is worth remembering as a result. To submerge it fully, the buoyant force becomes ρ_water V g = 1000 × 0.020 × 9.8 = 196 N while the weight is 600 × 0.020 × 9.8 = 118 N, so the extra downward force needed is 196 − 118 = 78 N.*

**Water flows at 2.0 m/s through a pipe of radius 4.0 cm which narrows to radius 2.0 cm. Find the speed in the narrow section and the pressure difference.**

8.0 m s$^{-1}$ in the narrow section; the wide section is 30 kPa higher.

*Continuity first: $A_1v_1 = A_2v_2$, and area goes as radius squared, so halving the radius quarters the area and quadruples the speed – 8.0 m s$^{-1}$. Then Bernoulli along a horizontal streamline, which requires steady, non-viscous, incompressible flow; state those conditions. $P_1 + ½\rho v_1^2 = P_2 + ½\rho v_2^2$, so $P_1 - P_2$ = ½(1000)(64 − 4) = 30 000 Pa. The wide, slow section has the HIGHER pressure, which students often get backwards.*

## Thermodynamics

**An ideal gas is compressed isothermally, and 400 J of work is done on it. How much heat flows, and in which direction?**

400 J flows out of the gas.

*Isothermal means the temperature does not change, and for an ideal gas the internal energy depends only on temperature, so $\Delta U = 0$. The first law $\Delta U = Q + W$ then gives $Q = -W = -400$ J, that is, 400 J leaves the gas. The reasoning chain – isothermal, so $\Delta U = 0$, so Q and W are equal and opposite – is what earns the points; the arithmetic is one line.*

**Two moles of an ideal gas at 300 K are heated at constant volume until the pressure doubles. Find the final temperature and the heat added, given C_V = 12.5 J/(mol · K).**

600 K; 7500 J.

*At constant volume the ideal gas law gives P/T constant, so doubling the pressure doubles the absolute temperature: 600 K. At constant volume no work is done, so all the heat becomes internal energy: Q = nC_VΔT = 2 × 12.5 × 300 = 7500 J. Kelvin is essential – using 300 °C or working in Celsius ratios gives a wrong answer with no warning.*



## Electricity and magnetism

**Two charges, +3.0 $\mu$C and −2.0 $\mu$C, sit 0.40 m apart. Find the electric potential at the midpoint, and the field magnitude there.**

Potential +4.5 × 10$^4$ V; field 1.1 × 10$^6$ N C$^{-1}$ pointing from the positive charge towards the negative one.

*Potential is a scalar and adds with signs: V = kq/r for each, with r = 0.20 m. That gives (8.99e9)(3.0e−6)/0.20 = 1.35e5 V and (8.99e9)(−2.0e−6)/0.20 = −0.90e5 V, summing to +4.5e4 V. The field is a vector: each charge produces a field of magnitude $kq/r^2$ pointing away from the positive and towards the negative, and at the midpoint both point the SAME way, so they add: 6.7e5 + 4.5e5 = 1.1e6 N C$^{-1}$. Treating the field like the potential and subtracting is the classic error here.*

**A 20 $\mu$F capacitor is charged to 50 V and then discharged through a 100 kΩ resistor. Find the stored energy and the time for the charge to fall to 37 per cent.**

25 mJ; 2.0 s.

*Energy is U = ½CV² = ½(20e−6)(2500) = 0.025 J. The fall to 1/e of the initial value is by definition one time constant, τ = RC = (1e5)(20e−6) = 2.0 s. Recognising that "37 per cent" means 1/e saves the entire exponential calculation – the exam uses that figure precisely because it wants the recognition.*

**A square loop of side 0.20 m lies in a field of 0.50 T perpendicular to its plane. The field falls to zero uniformly in 0.10 s. Find the induced e.m.f.**

0.20 V.

*Flux is Φ = BA = 0.50 × 0.040 = 0.020 Wb, and it falls to zero, so the change is 0.020 Wb over 0.10 s. Faraday's law gives ε = ΔΦ/Δt = 0.20 V. State that the induced current opposes the decrease, so it flows to maintain the original flux direction – Lenz's law is usually a separate scored statement, not an afterthought.*

## Optics and modern physics

**An object is 30 cm from a converging lens of focal length 10 cm. Find the image distance, the magnification, and describe the image.**

15 cm on the far side; magnification −0.50; real, inverted, smaller.

*Apply 1/s_o + 1/s_i = 1/f: 1/30 + 1/s_i = 1/10, so 1/s_i = 1/10 − 1/30 = 1/15 and s_i = 15 cm. Magnification m = −s_i/s_o = −0.50. Interpret the signs rather than reporting them: positive image distance means the image forms on the opposite side and is real; negative magnification means inverted; a magnitude below one means reduced. The description is worth as much as the number.*

**Light of wavelength 400 nm strikes a metal of work function 2.0 eV. Find the maximum kinetic energy of the emitted electrons.**

1.1 eV, about 1.7 × 10$^{-19}$ J.

*Photon energy E = hc/λ = (1240 eV · nm)/(400 nm) = 3.1 eV – using hc in electronvolt nanometres avoids two unit conversions and is worth memorising. Then K_max = E − φ = 3.1 − 2.0 = 1.1 eV. Note what does NOT change this: increasing the intensity emits more electrons at the same maximum energy, and that is the standard follow-up question.*