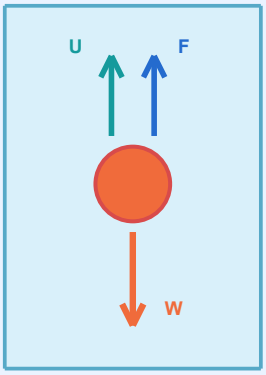
PEARSON EDEXCEL IAL PHYSICS | UNIT 1

LESSON 1.2.1

Density, Fluids and Viscosity

Density describes how mass is packed into volume. Fluid forces and viscosity explain floating, falling and flow.

forces on a sphere in a liquid



THE CORE RELATIONSHIPS

DENSITY

$\rho = m / V$

UPTHRUST

U = weight displaced

STOKES' LAW

$F = 6\pi\eta rv$

KEY FLUID IDEAS

LAMINAR FLOW

Smooth layers follow orderly streamlines with no large-scale mixing.

TURBULENT FLOW

Irregular motion contains eddies and mixing; Stokes' law is not valid.

UPTHRUST

The upward force equals the weight of fluid displaced by the object.

VISCOSITY

A measure of resistance to flow; larger viscosity means stronger viscous effects.

CORE HABIT

Draw every fluid force before calculating: weight downward, upthrust upward, and drag opposite the motion.

1 Density and upthrust

Density links mass and volume. Upthrust comes from pressure differences and equals the weight of fluid displaced.

DENSITY CALCULATION

DENSITY

$$\rho = \frac{m}{V}$$

SI unit: $kg\ m^{-3}$

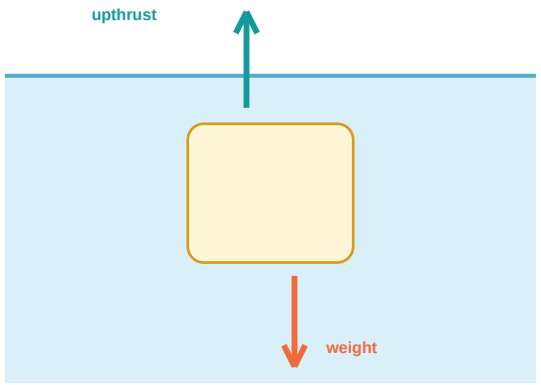
WORKED EXAMPLE

$m = 0.48\ kg,\ V = 2.0 \times 10^{-4}\ m^3$

$$\rho = \frac{0.48}{2.0 \times 10^{-4}}$$

$= 2400\ kg\ m^{-3}$

UPTHRUST FROM DISPLACED FLUID



displaced liquid creates an upward force

ARCHIMEDES' RELATIONSHIP

upthrust = weight of fluid displaced

$$U = \rho_{fluid} V_{displaced} g$$

Floating at rest: upthrust = weight. If weight is greater, the object accelerates downward until another force balance is reached.

AT REST: COMPARE WEIGHT AND UPTHRUST

FLOATS

$W = U$

no vertical acceleration

SINKS

$W > U$

accelerates downward

RISES

$U > W$

accelerates upward

CHECK THE DISPLACED VOLUME

A fully submerged object displaces its full volume. A floating object displaces only enough fluid for upthrust to balance its weight.

2 Viscosity and Stokes' law

Viscous drag opposes motion through a fluid. For a small slow sphere in laminar flow, drag is proportional to viscosity, radius and speed.

STOKES' LAW

$$F = 6\pi\eta r v$$

η = viscosity | r = sphere radius | v = speed

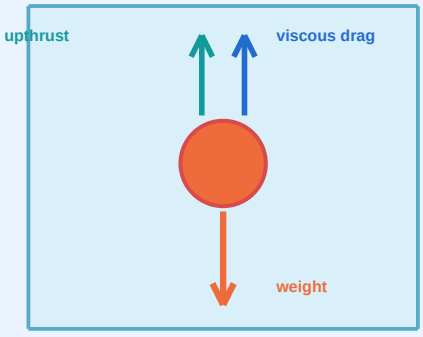
WHEN THE EQUATION IS VALID

1. small sphere
2. low speed
3. laminar flow
4. away from walls

FLOW PATTERN



CORE PRACTICAL: FALLING BALL



ball moving downward

AT TERMINAL SPEED

weight = upthrust + viscous drag

1. Measure the sphere radius and the liquid temperature.
2. Time the ball between marks after terminal speed is reached.
3. Calculate v = distance / time and use the force balance with Stokes' law.

Temperature matters: for most liquids, increasing temperature lowers viscosity.