

pressure, skin, drag and the price of going faster

## What counts as a fluid

- anything that can flow: liquids, gases and plasmas
- a fluid has **zero shear modulus**, so it cannot resist shearing at all
- an ideal fluid is incompressible, irrotational, nonviscous and in steady flow

## Pressure \*

definition

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

due to a liquid column

$$p = \rho g h$$

absolute pressure at depth  $h$

$$p = p_0 + \rho g h$$

gauge pressure

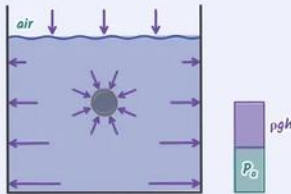
$$p - p_0 = \rho g h$$

SI unit and dimensions

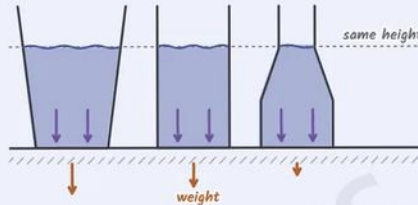
$$Pa = N/m^2, [L^{-1}M^{-1}T^{-2}]$$

pressure is a scalar. other units: 1 bar =  $10^5$  Pa, 1 torr = 1 mm of mercury

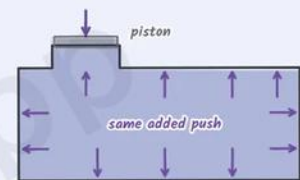
## Depth, shape, piston



deeper, more pressure, every way



same height, same push below



one push, the same extra everywhere

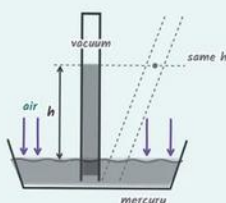
## What the column formula says

- $p = \rho g h$  has no area or shape term: pressure depends only on depth
- the hydrostatic paradox: connected vessels of any shape have liquid at the same level
- resolution: sloping walls push back with a vertical component, carrying the extra weight
- Pascal's law: extra pressure on an enclosed fluid goes undiminished everywhere

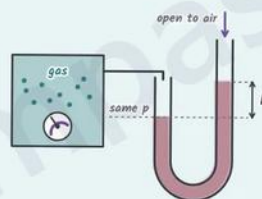
## Measuring pressure

- mercury barometer: inverted tube in a trough, Torricelli's vacuum above the column
- $p_0 = \rho g h$ : one atmosphere is 76 cm mercury = 760 torr
- open tube manometer: one limb open to air, height difference gives gauge pressure  $p - p_0$
- mercury is dense, keeping the column short, but is hazardous, no longer used in schools

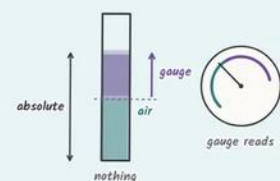
## Barometer, manometer, gauge \*



the column stands at  $h$ , tilted or not



$h$  shows the gauge pressure



the dial reads the part above the air