

SQ 5.1 What is meant by (i) cohesive force and (ii) viscosity?

Cohesive Force

The force of attraction between molecules of the same substance. It holds a liquid together, as in a drop of water or a globule of mercury.

Viscosity

The friction between adjacent layers of a flowing fluid. It opposes the sliding of one layer over another, so honey is more viscous than water.

SQ 5.2 Differentiate between streamline and turbulent flow of a fluid.

Streamline Flow	Turbulent Flow
<u>Smooth and regular</u> flow.	<u>Irregular and unsteady</u> flow.
Each particle follows a fixed streamline.	Particle paths keep changing.
Streamlines never cross.	Eddies form and velocity changes abruptly.

SQ 5.3 How does pressure change with depth in fluids?

Liquid Pressure

A point at depth h in a fluid of density ρ carries the weight of the fluid column above it.

$$P = \rho gh$$

Conclusion

For a given fluid,

$$\rho g = \text{constant}$$

$$P \propto h$$

Pressure increases with depth and is the same at all points at the same depth.

SQ 5.4 How is variation in pressure related to the speed of a fluid?

Bernoulli's Equation (Ideal Fluid)

$$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$$

According to Bernoulli's theorem, "where speed is high, pressure will be low".

Conclusion

High speed means low pressure.

SQ 5.5 How is flow rate related to the cross-sectional area and velocity of a fluid?

Volume Flow Rate

It is the volume of fluid crossing a cross-section in unit time. In time t the fluid moves a distance vt , so the volume Avt crosses area A

$$\frac{V}{t} = Av$$

Equation of Continuity

For steady flow of an incompressible fluid,

$$A_1 v_1 = A_2 v_2$$

The fluid moves faster where the area is smaller.

SQ 5.6 How can you study the variation in velocity of a fluid at different points in a hose of varying diameter?

We can study the variation in velocity of a fluid at different points in a hose of varying diameter by the equation of continuity.

$$Av = \text{constant}$$

or

$$v \propto \frac{1}{d^2}$$

Results

Velocity is more from narrow diameter.

Velocity is less from wider diameter.

SQ 5.7 How does an object float or sink according to Archimedes' principle?

Floating

Upthrust equals its weight. A body less dense than the fluid floats.

$$F = W$$

Sinking

Weight exceeds the full upthrust. A body denser than the fluid sinks.

$$W > F$$

SQ 5.8 How did Archimedes reportedly discover the principle that bears his name?

Observation

When Archimedes sat in a bath tub, water came out. He felt lighter in the water.

Discovery

A body gets an upthrust equal to the weight of fluid displaced. He tested the king's crown with it.

SQ 5.9 Why is standing near a fast-moving train dangerous? Explain briefly.

Low Pressure

Air between person and train moves fast, so its pressure falls.

According to Bernoulli's theorem, "where speed is high, pressure will be low".

$$P + \frac{1}{2}\rho v^2 = \text{constant}$$

Danger

The higher pressure behind and the lower pressure in front create a pressure difference that pushes the person towards the train.

SQ 5.10 What are some potential applications of superfluidity?

High-Field Magnets

Superfluid helium-4 carries heat away very efficiently, so it is used as a coolant for high-field magnets.

Other Uses

Cooling advanced particle detectors. Research into superconductivity and the behaviour of matter near absolute zero.

SQ 5.11 Differentiate between stress, strain and Young's modulus. Write their SI units.

Quantity	Definition	Formula	SI Unit
Stress	Force per unit area.	$\sigma = F/A$	pascal (Pa)
Strain	Fractional change in length.	$\epsilon = \Delta L/L$	<u>None</u>
Young's Modulus	Stress per unit strain.	$Y = \sigma/\epsilon$	pascal (Pa)

CRQ 5.1 The ratio stress/strain remains constant for small deformation. What happens to this ratio when the deformation becomes very large?

The ratio no longer stays constant; it decreases.

Small Deformation

Within the limit of proportionality stress is proportional to strain, so

$$\frac{\sigma}{\epsilon} = Y = \text{constant}$$

Large Deformation

Beyond the limit of proportionality strain grows faster than stress, so the ratio falls and the material may finally break.

CRQ 5.2 Pure water spreads on a flat glass plate, while mercury forms small globules on the same plate. Why?

Water on Glass

Adhesion between water and glass is greater than cohesion between water molecules, so water wets the glass and spreads.

Mercury on Glass

Cohesion between mercury molecules is greater than adhesion to glass, so mercury does not wet it. Surface tension pulls it into small globules.

CRQ 5.3 According to Bernoulli's theorem, pressure in a pipe of uniform radius should remain uniform, but actually it decreases along the pipe. Why?

Ideal Fluid

Bernoulli's equation assumes zero viscosity, so pressure would stay uniform.

Real Fluid

Viscosity causes friction and turns energy into heat, so a pressure drop is needed to keep it flowing.

CRQ 5.4 Why are the wings of an aeroplane rounded outward on top and comparatively flat underneath?

Air Speed

Air moves faster over the curved top than under the flat base.

According to Bernoulli's theorem, "where speed is high, pressure will be low".

Lift

Lower pressure above gives an upward pressure difference.

CRQ 5.5 What is the difference between a real fluid, an ideal fluid and a superfluid? Which of these actually exist?

Ideal Fluid	Real Fluid	Superfluid
No viscosity and incompressible .	It has viscosity.	Zero viscosity with frictionless flow.
<u>Cannot exist practically</u> .	Water, petrol and honey are real fluids.	Helium-4 near absolute zero is a real example.

CRQ 5.6 Why is the study of superfluids important for advancing our knowledge of low-temperature physics?

Importance

Superfluids flow without losing energy and pass through the narrowest spaces. It explains superconductivity and matter near absolute zero.

Example

Helium-4 cools cryogenic research and magnets.