inkPhysics

QUESTION WORKBOOK

Fluids: pressure, upthrust and viscosity

Materials · Year 12

CIE 4.3.2, 4.3.3, 4.3.4, 4.3.5, 4.3.6 · OCR A 3.2.4(b), 3.2.4(c)

20 questions · 61 marks

NAVY SCREEN EDITION

inkphysics.co.uk

SECTION A · Warm-up

A1 State the equation for the pressure due to a column of fluid, defining each symbol, and state one quantity the pressure does not depend on. [2]

A2 Calculate the pressure due to the water at the bottom of a swimming pool 2.5 m deep (density of water 1000 kg m^{-3}). [2]

A3 State what is meant by upthrust and give its size in terms of the fluid displaced. [2]

A4 State the condition, in terms of forces, for an object to float in a fluid, and the condition this places on the object's average density. [2]

A5 Distinguish between laminar flow and turbulent flow. [2]

SECTION B · Standard

B1 A stone of volume 3.0×10^{-4} m³ is fully submerged in water. Calculate the upthrust on it. [3]

B2 A submarine cruises 30 m below the surface of sea water of density 1025 kg m^{-3}. Calculate the pressure due to the water at this depth, and state what must be added to find the total pressure on the hull. [3]

B3 Explain, in terms of pressure, why the upthrust on a submerged object acts upwards. [2]

B4 An iceberg of density 920 kg m^{-3} floats in fresh water of density 1000 kg m^{-3}. Calculate the fraction of its volume below the surface. [3]

B5 State the conditions under which Stokes' law applies to the drag on a moving sphere. [2]

B6 A cube of side 0.10 m is held fully submerged in fresh water (density 1000 kg m^{-3}) with its top face horizontal at a depth of 0.50 m. Calculate the water pressure on the top face and on the bottom face, and hence the resultant force the water pressure exerts on the cube. (g = 9.81 m s^{-2}.) [4]

B7 A flat rectangular pontoon of surface area 3.0 m^2 floats on a lake. When a person of weight 600 N steps aboard, the pontoon floats lower in the water. Calculate the extra depth by which it sinks. (Density of water 1000 kg m^{-3}; g = 9.81 m s^{-2}.) [3]

B8 A helium balloon has a total volume of 12 m^3 and a total weight, including the helium and its load, of 90 N. The density of the surrounding air is 1.2 kg m^{-3}. Calculate the upthrust on the balloon and the resultant force acting on it, and state what happens when it is released. (g = 9.81 m s^{-2}.) [3]

SECTION C · Stretch

C1 A sphere of radius 1.5 mm moves at 0.12 m s^{-1} through oil of viscosity 0.25 Pa s. Calculate the viscous drag on it. [3]

C2 A small sphere falls through glycerol of viscosity 0.85 Pa s. Its weight exceeds the upthrust on it by 1.8×10^{-4} N, and its radius is 1.0 mm. Calculate its terminal velocity. [4]

C3 Estimate the depth of fresh water that produces a pressure equal to one atmosphere (1.01×10^5 Pa), and comment on what this means for a diver at 20 m. [3]

C4 A student measures the viscosity of syrup by timing a ball bearing falling between two marks. Explain why the marks must be placed well below the surface, and why the temperature must be recorded. [3]

C5 A steel sphere of radius 0.60 mm (density 7800 kg m^{-3}) falls at terminal velocity through oil of density 920 kg m^{-3} and viscosity 0.30 Pa s. Assume the flow around the sphere is laminar. Calculate the terminal velocity. (g = 9.81 m s^{-2}.) [5]

C6 A food manufacturer requires its syrup to have a viscosity of at least 2.0 Pa s at 20 °C. In a quality-control test at 20 °C, a ball of radius 1.5 mm falls through a sample at a steady speed of 9.5 mm s^{-1}; its weight exceeds the upthrust on it by 5.7×10^{-4} N. Deduce whether the batch meets the requirement. [4]

C7 A small steel sphere is released from rest at the surface of a deep column of glycerol. Describe and explain, in terms of the forces acting, the motion of the sphere from release until it falls at a steady speed. [6]