



Attempt questions first; check the separate key afterward. Take $g = 10 \text{ m/s}^2$ and water density $= 1000 \text{ kg/m}^3$. State any ideal-flow assumptions used.

A. Very short answers - 1 mark each

1. Define pressure and state its SI unit.
2. Why does a liquid exert a force normal to a surface at rest?
3. Distinguish streamline flow from turbulent flow.
4. Define coefficient of viscosity and give its SI unit.
5. What is terminal speed?
6. Define surface tension and state its SI unit.
7. What is the angle of contact?
8. Why does a small liquid drop tend to be spherical?

B. Short answers / practice - 2 marks each

9. State Pascal's law and name two applications.
10. Why does pressure at a fixed depth not depend on the shape of the vessel?
11. A hydraulic lift has piston areas 5 cm^2 and 500 cm^2 . Find the load supported by a 100 N effort.
12. Water flows through areas 8 cm^2 and 2 cm^2 . If its speed in the wider part is 0.5 m/s , find its speed in the narrower part.
13. Why do raindrops eventually fall with nearly constant speed?
14. Explain why detergent helps water spread on clothes.
15. How does capillary rise change if the tube radius is doubled? State the assumptions.
16. Why is the excess pressure inside a soap bubble twice that inside a liquid drop of equal radius and surface tension?

C. Application / reasoning - 3 marks each

17. Find gauge and absolute pressure 5 m below water. Use atmospheric pressure $1.0 \times 10^5 \text{ Pa}$.
18. Water flows horizontally at 2 m/s through one section and 6 m/s through another. Find the pressure difference, neglecting viscosity.
19. A tank has a small hole 1.25 m below the free surface. Find the efflux speed. State why the free-surface speed can be neglected.

20. A wire of length 5 cm supports a soap film with surface tension 0.03 N/m . Find the force needed to hold it and work to move it by 2 cm .

21. A water drop of radius 1 mm has surface tension 0.072 N/m . Find its excess pressure and surface energy.

22. Water rises in a capillary of radius 0.5 mm . Calculate the rise for surface tension 0.072 N/m and contact angle zero.

23. State Stokes' law and its conditions. How does terminal speed vary with sphere radius?

24. Explain dynamic lift using the pressure difference around an aerofoil. State the assumptions of the ideal-flow explanation.

25. A sphere of density 7800 kg/m^3 and radius 0.5 mm falls through oil of density 900 kg/m^3 and viscosity 0.5 Pa s . Find its Stokes terminal speed.

D. Extended practice - 5 marks each

26. Derive the pressure-depth relation for a liquid at rest. Use it to explain a hydraulic press with a labelled diagram.
27. Derive Bernoulli's equation for steady, incompressible, non-viscous flow. State its limitations and obtain Torricelli's law.
28. Derive the terminal speed of a small sphere falling through a viscous liquid, including buoyancy. Explain the approach to terminal speed.
29. Derive the excess pressure inside a liquid drop and a soap bubble using force balance or virtual work.
30. Derive the capillary-rise formula. Explain rise in water and depression in mercury using contact angle and intermolecular forces.

ANSWER KEY - Numerical / closed questions

11) 10000 N . 12) 2 m/s . 15) It halves for unchanged liquid and contact angle. 17) $5 \times 10^4 \text{ Pa}$ gauge; $1.5 \times 10^5 \text{ Pa}$ absolute. 18) 16000 Pa , wider section at higher pressure. 19) 5 m/s . 20) 0.003 N ; $6 \times 10^{-5} \text{ J}$. 21) 144 Pa ; $9.05 \times 10^{-7} \text{ J}$. 22) 0.0288 m . 23) Terminal speed proportional to r^2 in the Stokes regime. 25) $7.67 \times 10^{-3} \text{ m/s}$.