Mechanical Properties of Fluids

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. The total (absolute) pressure at a depth of 8 m in water is (atmospheric pressure 1.0×10^5 N/m^2, g = 10 m/s^2):

(a) 8×10^5 N/m^2 **(b)** 8×10^4 N/m^2 **(c)** 8×10^3 N/m^2 **(d)** 1.8×10^5 N/m^2

2. In a hydraulic lift, the small piston has diameter 5 cm and the large one 23 cm. A force of 160 N on the small piston can lift a load of:

(a) 736 N **(b)** 7.56 N **(c)** 3,385.6 N **(d)** 6,771.2 N

3. Water flows at 2 m/s through a pipe of diameter 5 cm into a pipe of diameter 1 cm. Its speed in the second pipe is:

(a) 2 m/s **(b)** 10 m/s **(c)** 50 m/s **(d)** 0.08 m/s

4. The excess pressure inside a liquid drop of radius 8 mm (surface tension 0.02 N/m) is:

(a) 5 N/m^2 **(b)** 0.005 N/m^2 **(c)** 2.5 N/m^2 **(d)** 10 N/m^2

5. Pascal's law says that pressure applied to an enclosed fluid is:

(a) transmitted undiminished to every part of the fluid

(b) halved at each point

(c) lost at the walls

(d) increased at the bottom only

6. Water flows out of a small hole 16.2 m below the surface in a tank. The speed of efflux is: (Take g = 10 m/s^2.)

(a) 20 m/s **(b)** 36 m/s **(c)** 162 m/s **(d)** 18 m/s

7. How high does water rise in a clean glass capillary tube of radius 0.2 mm? (Surface tension 0.06 N/m, angle of contact 0°, density 1000 kg/m^3, g = 10 m/s^2)

(a) 600 mm **(b)** 60 mm **(c)** 120 mm **(d)** 30 mm

8. Assertion (A): In a hydraulic press with pistons of diameter 5 cm and 15 cm, a force of 10 N on the small piston produces 90 N on the large one.
Reason (R): By Pascal's law the force is the same on both pistons.

(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. Find the gauge pressure and the total pressure at a depth of 48 m in a lake. (Atmospheric pressure 1.0×10^5 N/m^2, density of water 1000 kg/m^3, g = 10 m/s^2)

10. A car of mass 1000 kg rests on the large piston (diameter 19 cm) of a hydraulic lift. What force on the small piston (diameter 4 cm) will hold it up? (Take g = 10 m/s^2.)

11. Water flows at 9 m/s through a pipe of diameter 4 cm, which joins a pipe of diameter 5 cm. Find the speed in the second pipe and the volume flow rate ($\pi = 22/7$). (2 decimal places where needed.)

12. Water flows through a horizontal pipe. Its speed is 8 m/s at one point and 10 m/s at another. Find the difference in pressure between the two points. (Density 1000 kg/m^3)

13. A tank has a hole of area 5 cm^2 at a depth of 0.8 m below the water surface. Find the speed of efflux and the volume of water flowing out per second. (Take g = 10 m/s^2.)

14. How much work is needed to blow a soap bubble of radius 7 cm, if the surface tension of the solution is 0.06 N/m? ($\pi = 22/7$)

15. Find the excess pressure inside (a) a liquid drop and (b) a soap bubble, each of radius 7 mm, if the surface tension is 0.05 N/m.

16. Find the viscous drag on a sphere of radius 7 mm moving at 1.9 m/s through a fluid of viscosity 0.1 Pa s. ($\pi = 22/7$)

Section C — Word problems — 4 × 4 = 16 marks

17. A metal ball of radius 4 mm and density 11300 kg/m^3 falls through a liquid of density 1000 kg/m^3 and viscosity 0.1 Pa s. Find its terminal velocity. (Take g = 10 m/s^2.) (2 decimal places where needed.)

18. A hydraulic jack has pistons of diameter 2 cm and 9 cm. (a) What force on the small piston lifts an 800 kg load? (b) If the small piston moves down 45 cm, how far does the load rise? (c) Show that the work done on each piston is the same. (Take g = 10 m/s^2.)

19. Water flows through a horizontal pipe that narrows from 5 cm to 2 cm in diameter. The speed in the wide part is 4 m/s. Find (a) the speed in the narrow part, (b) the pressure difference between the two parts. Which part has lower pressure? (Density 1000 kg/m^3) (2 decimal places where needed.)

20. Two clean glass capillary tubes of radii 0.5 mm and 2 mm stand in water. Find the height of water in each and the difference in levels. (S = 0.07 N/m, angle of contact 0°, ρ = 1000 kg/m^3, g = 10 m/s^2)

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Answer key

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Q	Answer	Working
1	**(d) 1.8 × 10^5 N/m^2**	$p = p_0 + \rho gh$
2	**(c) 3,385.6 N**	$F_2 = F_1 \times A_2/A_1 = F_1(d_2/d_1)^2$
3	**(c) 50 m/s**	$A_1v_1 = A_2v_2$
4	**(a) 5 N/m^2**	2S/r
5	**(a) transmitted undiminished to every part of the fluid**	—
6	**(d) 18 m/s**	$v = \sqrt{(2gh)}$
7	**(b) 60 mm**	$h = 2S/(r\rho g)$
8	**(c) A is true, but R is false.**	A is true: $F_2 = 10 \times (15/5)^2 = 90$ N. R is false.
9	**4.8 × 10^5 N/m^2; 5.8 × 10^5 N/m^2**	gauge = ρgh; total = p_0 + ρgh
10	**443.21 N**	$F_1 = mg \times (d_1/d_2)^2$
11	**5.76 m/s; 0.0113 m^3/s**	$A_1v_1 = A_2v_2$; flow rate = Av
12	**18,000 N/m^2, higher where the speed is 8 m/s**	$p_1 - p_2 = ½\rho(v_2^2 - v_1^2)$
13	**4 m/s; 0.002 m^3/s = 2 L/s**	$v = \sqrt{(2gh)}$; flow = av
14	**0.00739 J**	two surfaces: $W = S \times 2 \times 4\pi r^2$
15	**(a) 14.29 N/m^2; (b) 28.57 N/m^2**	drop 2S/r; bubble 4S/r (two surfaces)
16	**0.0251 N**	Stokes: $F = 6\pi\eta rv$
17	**3.66 m/s**	$v_t = 2r^2(\rho - \sigma)g/(9\eta)$
18	**(a) 395.06 N. (b) 2.22 cm. (c) The same volume of liquid moves, so $F_1x_1 = F_2x_2$: no energy is gained.**	$A_1x_1 = A_2x_2$
19	**(a) 25 m/s; (b) 304,500 N/m^2; the narrow part has lower pressure**	continuity, then Bernoulli: $p_1 - p_2 = ½\rho(v_2^2 - v_1^2)$
20	**28 mm and 7 mm; difference 21 mm**	$h = 2S/(r\rho g)$: the narrower tube has the higher column

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