POSTAL
Book Package

2023

GATE • PSUs

PRODUCTION AND INDUSTRIAL ENGINEERING

Objective Practice Sets

General Engineering : Volume VI

Fluid Mechanics

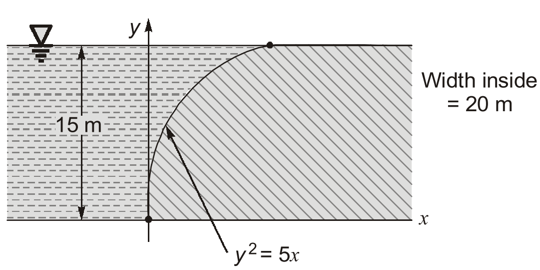
MADE EASY
Publications

Fluid Mechanics

Q.1 If the stream function is given by $\psi = 3xy$, then the velocity at a point (3, 2) will be
(a) 7.8 m/s (b) 10.11 m/s
(c) 11.39 m/s (d) 10.816 m/s

Q.2 A piping system, consists of three pipes arranged in series, the length of the pipes are 1200 m, 1750 m and 600 m and diameters are 750 mm, 680 mm, 850 mm respectively. The equivalent length of pipe of diameter 680 mm is______m. (Consider same friction factor for all pipes).

Q.3 A dam is having a curved surface as shown in the figure. The net force acting on the dam is _________ MN. Use ρ_{water} = 1000 kg/m^3, g = 9.81 m/s^2.



Q.4 The difference in pressure across an air bubble of diameter 0.002 m immersed in water (Surface tension = 0.072 N/m) is
(a) 72 N/m^2 (b) 144 N/m^2
(c) 288 N/m^2 (d) 140 N/m^2

Q.5 For a certain two-dimensional incompressible flow, velocity field is given by $\vec{V} = x\hat{i} - y\hat{j}$, the equation of stream line passing through the point (1, 1) is:
(a) $xy - 1 = 0$ (b) $\frac{x}{y} - 2 = 0$
(c) $x - y = 0$ (d) $x(y - 1) = 1$

Q.6 Consider fully developed flow in a circular pipe with negligible entrance length effects. Assuming the mass flow rate, density and friction factor to be constant, if the length of the pipe is halved and the diameter is doubled, then ratio of initial to final loss due to friction $\left(\frac{h_{L1}}{h_{L2}}\right)$ is________.

Q.7 Oil in a hydraulic cylinder is compressed from an initial volume of 3 m^3 to 2.94 m^3. If the pressure of oil in the cylinder changes from 120 MPa to 200 MPa during compression, the bulk modulus of elasticity of oil is________ MPa.

Q.8 If the velocity distribution over a plate is given by $u = \frac{2}{3}y - y^2$ in which u is the velocity in metre per second at a distance y metre above the plate. Determine the shear stress at y = 0.15 m. Take dynamic viscosity of fluid as 8.63 Poise.
(a) 0.5756 N/m^2 (b) 0.3167 N/m^2
(c) 0.2367 N/m^2 (d) 0.1126 N/m^2

Q.9 A cube of ice floats partly in water and oil. The ratio of the ice immersed in water to that of oil if the density of oil, ice and water are 800 kg/m^3, 900 kg/m^3 and 1000 kg/m^3 respectively, is ___________.

Q.10 The water is flowing through a taper pipe of length 100 m having diameters 600 mm at the upper end and 300 mm at the lower end, at the rate of 50 litres/seconds. The pipe has a slope of 1 in 30. Find the pressure at the lower end if the pressure at the higher end is 19.62 N/cm^2.
(a) 21.623 N/cm^2 (b) 22.867 N/cm^2
(c) 24.621 N/cm^2 (d) 27.128 N/cm^2

Q.11 Two reservoirs are connected by two pipe 1 and 2 of same length and friction factor, in series. If the diameter of pipe 1 is 25% larger than that of pipe 2, the ratio of head loss in pipe 1 to that of pipe 2 is _________.

Answers Fluid Mechanics

1. (d)	2. (2681.83)	3. (49.3556)	4. (b)	5. (a)	6. (64)	7. (4000)	8. (b)
9. (1)	10. (b)	11. (0.32768)	12. (a)	13. (77.94)	14. (d)	15. (d)	16. (d)
17. (34.01)	18. (d)	19. (a)	20. (2)	21. (209.47)	22. (116.37)	23. (b)	24. (b)
25. (d)	26. (–9)	27. (0)	28. (a)	29. (d)	30. (b)	31. (a)	32. (2)
33. (c)	34. (a)	35. (a)	36. (1.4)	37. (922.5)	38. (37.5)	39. (785.4)	40. (c)
41. (183.076)	42. (1.43)	43. (4.45)	44. (1.473)	45. (a)	46. (1.461)	47. (18.0277)	48. (1652)
49. (b)	50. (c)	51. (b)	52. (b)	53. (b)	54. (c)	55. (a)	56. (b)
57. (173.596)	58. (c)	59. (a)	60. (6.96)	61. (35.40)	62. (a)	63. (c)	64. (c)
65. (b)	66. (d)	67. (a)	68. (a)	69. (Sol.)	70. (b)	71. (c)	72. (d)
73. (a)	74. (b)	75. (a)	76. (c)	77. (b)	78. (d)	79. (d)	80. (b)
81. (c)	82. (c)	83. (c)	84. (a)	85. (c)	86. (d)	87. (d)	88. (a)
89. (c)	90. (c)	91. (c)	92. (d)	93. (b)	94. (b)		

Explanations Fluid Mechanics

1. (d)

$$u = -\frac{\partial \psi}{\partial y} = -\frac{\partial}{\partial y}(3xy) = -3x$$

$$v = \frac{\partial \psi}{\partial x} = \frac{\partial}{\partial x}(3xy) = 3y$$

$$V = \sqrt{u^2 + v^2}$$

$$= \sqrt{(-3x)^2 + (3y)^2}$$

$$= \sqrt{9x^2 + 9y^2}$$

$$= 3\times\sqrt{x^2+y^2} = 3\times\sqrt{9+4}$$

$$= 10.816 \text{ m/s}$$

2. (2681.83)

$$h_L = \frac{flQ^2}{12.1D^5}$$

For pipe in series,

$$\frac{fl_{eq}Q^2}{12.1D_{eq}^5} = \frac{fl_1Q^2}{12.1D_1^5} + \frac{fl_2Q^2}{12.1D_2^5} + \frac{fl_3Q^2}{12.1D_3^5}$$

$$\frac{l_{eq}}{(680)^5} = \frac{1200}{(750)^5} + \frac{1750}{(680)^5} + \frac{600}{(850)^5}$$

$$l_{eq} = 2681.83 \text{ m}$$

3. (49.3556)

Horizontal force,

$$F_H = \rho g \times \frac{H}{2} \times H \times W$$

$$= 1000 \times 9.81 \times \frac{15^2}{2} \times 20 \text{ N}$$

$$= 22.0725 \text{ MN}$$

Vertical force,

F_r = Weight of water retained upto the free surface

$$= \rho g W \int dA = \rho g W \int \frac{y^2}{5} dy$$

$$= \frac{1000 \times 9.81 \times 20}{5} \times \left(\frac{15^3}{3}\right) \text{N}$$

$$= 44.145 \text{ MN}$$

$$F_{net} = \sqrt{F_H^2 + F_r^2} = 49.3556 \text{ MN}$$

4. (b)

$$\Delta P = \frac{4\sigma}{d}$$

$$= \frac{4 \times 0.072}{0.002}$$

$$\Delta P = 144 \text{ N/m}^2$$

Let the flow rate be Q.

$$v_1 = \frac{4Q}{\pi D_1^2}$$

$$v_2 = \frac{4Q}{\pi D_2^2}$$

Head loss, $h_f = \frac{(v_1 - v_2)^2}{2g}$

Applying modified Bernoulli's between (1) and (2)

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + h_f \quad ...(1)$$

Since, both sections are just across the jump

So, $z_1 = z_2$

So. eq. (1) becomes

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + h_f$$

or $$\frac{P_2 - P_1}{\rho g} = \frac{v_1^2}{2g} - \frac{v_2^2}{2g} - h_f$$

$$= \frac{v_1^2}{2g} - \frac{v_2^2}{2g} - \frac{(v_1 - v_2)^2}{2g}$$

$$\frac{\Delta P}{\rho g} = \frac{16Q^2}{2g\pi^2 D_1^4} - \frac{16Q^2}{2g\pi^2 D_2^4} - \frac{\left(\frac{4Q}{\pi D_1^2} - \frac{4Q}{\pi D_2^2}\right)^2}{2g}$$

for maximum pressure increase, $\frac{d(\Delta P)}{d\left(\frac{D_1}{D_2}\right)} = 0$

which gives $2\left(\frac{D_1}{D_2}\right) - 4\left(\frac{D_1}{D_2}\right)^3 = 0$

$$\frac{D_1}{D_2} = \frac{1}{\sqrt{2}}$$

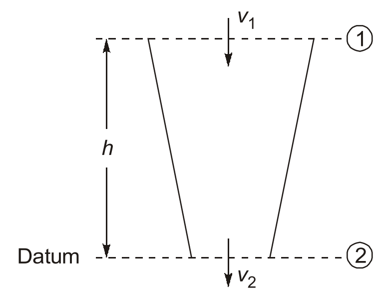
$$\Rightarrow \quad \frac{D_2}{D_1} = \sqrt{2}$$

15. (d)

$$A_1 = \frac{\pi}{4} \times (0.02)^2 = 3.14 \times 10^{-4}\ \text{m}^2$$

$$v_1 = \frac{Q}{A_1} = \frac{0.01}{60 \times 3.14 \times 10^{-4}}$$

$$= 0.531\ \text{m/s}$$



Applying Bernoulli's theorem at the top and bottom of the sprue, we get

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$\therefore \quad p_1 = p_2 = p_{atm}$

and $\quad z_2 = 0,\ z_1 = h = 0.2$ m

$$\frac{(0.531)^2}{2g} + 0.2 = \frac{v_2^2}{2g}$$

$$v_2 = \sqrt{2 \times 9.81 \times 0.2 + 0.531^2}$$

$$v_2 = 2.05\ \text{m/s}$$

$$A_2 = \frac{Q}{v_2} = \frac{0.01}{60 \times 2.05}$$

$$= 8.13 \times 10^{-5}\ \text{m}^2$$

$$A_2 = 81.3\ \text{mm}^2$$

16. (d)

The length in the perimeter, $2\pi r$ and there is two surfaces of rubber sheet (inside and outside) by force balance,

$$\sigma \times 2\pi r \times 2 = mg$$

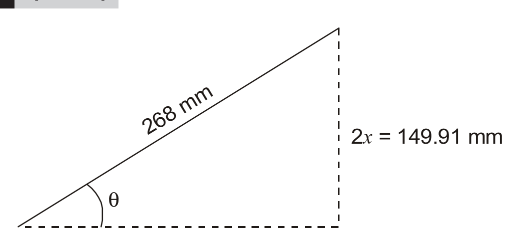
$$mg = \frac{1}{2} \times \frac{4}{3}\pi r^3 \rho g$$

$$= \frac{1}{2} \times \frac{4}{3} \times \pi \times 0.25^3 \times 1000 \times 9.81 = 321.02\ \text{N}$$

$$\sigma = \frac{321.03}{2 \times 2\pi \times 0.25} \Rightarrow 102.187\ \text{N/m}$$

$$\sigma \approx 102.2\ \text{N/m}$$

17. (34.01)



Given: Applying hydrostatic law;