Mechanical Properties of Fluids

Pressure and Density

2011

1. A body floats in water with 40% of its volume outside water. When the same body floats in oil 60% of its volume remains outside oil. Then relative density of oil is

a) 0.9 b) 1.0 c) 1.2 d) 1.5

2010

2. Three liquids of equal masses are taken in three identical cubical vessels A, B and C. Their densities are ρ_A, ρ_B and ρ_C respectively but $\rho_A < \rho_B < \rho_C$. The force exerted by the liquid on the base of the cubical vessel is

a) Maximum in vessel C b) Minimum in vessel C

c) The same in all the vessels d) Maximum in vessel A

2008

3. A common hydrometer reads specific gravity of liquids. Compared to the 1.6 mark of the stem the mark 1.5 will be

a) Upwards

b) Downwards

c) In the sample place

d) May be upward or downward depending upon the hydrometer

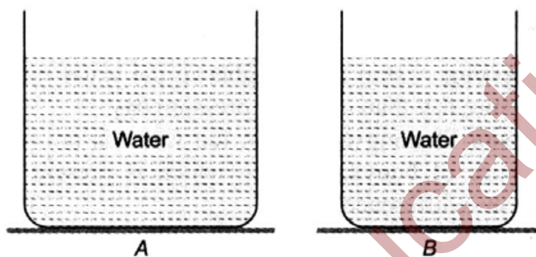
2006

4. By sucking through a straw a student can reduce the pressure in his lungs to 750 mm of Hg (density = $13.6 gcm^{-3}$). **Using the straw, he can drink water from a glass up to a maximum depth of**

a) 10cm b) 75cm c) 13.6cm d) 1.36 cm

2005

5. From the adjacent figure, the correct observation is



a) The pressure on the bottom of tank A is greater than at the bottom of B

b) The pressure on the bottom of the tank A is smaller than at the bottom of B

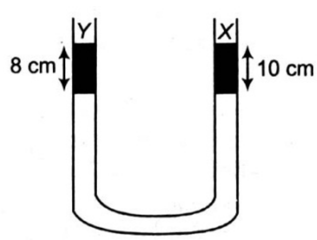
c) The pressure depends on the shape of the container

d) The pressure on the bottom of A and B is the same

Pascal's Law and Archimedes Principle

2010

6. A liquid X of density $3.36 g/cm^3$ **is poured in a U-tube in right arm with height 10cm, which contains Hg. Another liquid Y is poured in left arm with height 8cm. Upper levels of X and Y is same. What is the density of Y**



a) 0.8 g/cc b) 1.2 g/cc c) 1.4 g/cc d) 1.6 g/cc

2009

7. Assertion (A): A floats higher in the water on a high pressure day than on a low pressure day.

Reason (R): Floating of ship in the water is not possible because of buoyancy force which is present due to pressure difference.

a) Both assertion and reason are true and reason is the correct explanation of assertion.

b) Both assertion and reason are true but reason is not the correct explanation of assertion.

c) Assertion is true but reason is false.

d) Both assertion and reason are false.

2008

8. An ice block floats in a liquid whose density is less than water. A part of block is outside the liquid. When whole of ice has melted, the liquid level will

a) Rise b) Go down

c) Remain same d) First rise then go down

9. A cube made of material having a density of $0.9\times10^{3} kg-m^{-3}$ floats between water and a liquid of density $0.7\times10^{3} kg-m^{-3}$, which is immiscible with water. What part of the cube is immersed in water?

a) $\frac{1}{3}$ b) $\frac{2}{3}$ c) $\frac{3}{4}$ d) $\frac{3}{7}$

2007

10. **Assertion (A): Taking into account the fact that any object which floats must have an average density less than that of water during world war I, a number of cargo vessels were made of concrete.**

Reason (R): Concrete cargo vessels were filled with air.

a) Both assertion and reason are true and reason is the correct explanation of assertion.

b) Both assertion and reason are true but reason is not the correct explanation of assertion.

c) Assertion is true but reason is false.

d) Both assertion and reason are false.

11. **A body floats with one-third of its volume outside water and ¾ of its volume outside another liquid. The density of the other liquid is**

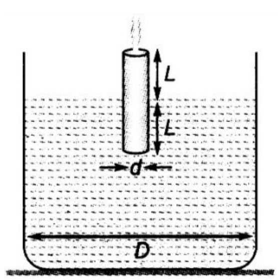
a) $\frac{9}{4} g\, cc^{-1}$ b) $\frac{4}{0} g\, cc^{-1}$ c) $\frac{8}{3} g\, cc^{-1}$ d) $\frac{3}{8} g\, cc^{-1}$

2005

12. **For a constant hydraulic stress on an object, the fractional change in the object's volume** $(\Delta V / V)$ **and its bulk modulus (B) are related as**

a) $\frac{\Delta V}{V} \propto B$ b) $\frac{\Delta V}{V} \propto \frac{1}{B}$ c) $\frac{\Delta V}{V} \propto B^2$ d) $\frac{\Delta V}{V} \propto B^{-2}$

13. **A candle of diameter d is floating on a liquid in a cylindrical container of diameter D (D>>d) as shown in figure. If it's burning at the rate of** $2cmh^{-1}$**, then the top of the candle will**



a) Remain at the same height b) Fall at the rate of $1cmh^{-1}$

c) Fall at the rate of $2cmh^{-1}$ d) Go up at the rate of $1cmh^{-1}$

Fluid Flow

2009

14. In a streamline flow

a) The speed of a particle always remains same

b) The velocity of a particle always remains same

c) The kinetic energies of all particles arriving at a given point are the same

d) The momentum of all the particle arriving at a given point are the same

2008

15. A rectangular vessel when full of water, takes 10 min to be emptied through an orifice in its bottom. How much time will it take to be emptied when half filled with water?

a) 9 min b) 7 min c) 5 min d) 3 min

16. An air bubble of radius 1cm rises from the bottom portion through a liquid of density $1.5\,gcc^{-1}$ at a constant speed of $0.25\,cms^{-1}$. If the density of air is neglected, the coefficient of viscosity of the liquid is approximately (in Pa).

a) 13000 b) 1300 c) 130 d) 13

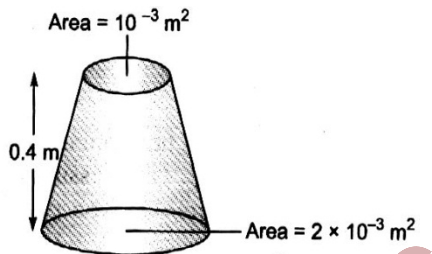
17. If the terminal speed of a sphere of gold (density$=19.5kg-m^3$) is $0.2ms^{-1}$ in viscous liquid (density$1.5kg-ms^3$), find the terminal speed of a sphere of silver (density $10.5kg-ms^{-3}$), of the same size in the same liquid

a) $0.4ms^{-1}$ b) $0.133ms^{-1}$ c) $0.1ms^{-1}$ d) $0.2ms^{-1}$

18. Water is filled in a cylindrical container to a height of 3m. The ratio of the cross-sectional area of the orifice and the breaker is 0.1. The square of the speed of the liquid coming out from the orifice is $(g = 10ms^{-2})$

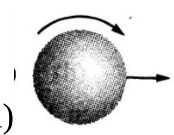
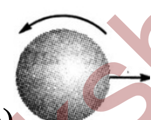
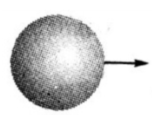
a) $50m^2s^{-2}$ b) $50.5m^2s^{-2}$ c) $51m^2s^{-2}$ d) $52m^2s^{-2}$

19. A uniformly tapering vessel is filled with a liquid of density $900kg - m^3$ **. The force that acts on the base of the vessel due to the liquid is** $(g = 10ms^{-2})$

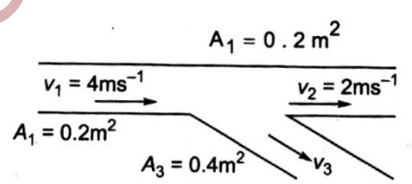


a) 3.6 N b) 7.2 N c) 9.0N d) 14.4N

20. To get the maximum flight a ball must be thrown as

a)  b)  c)  d) Any of a, b and c

21. In the figure, the velocity v_3 **will be**



a) Zero b) $4ms^{-1}$ c) $1ms^{-1}$ d) $3ms^{-1}$

2007

22. A capillary tube is attached horizontally to a constant head arrangement. If the radius of the capillary tube is increased by 10%, then the rate of flow of liquid will change nearly by

a) +10% b) +46% c) -10% d) -40%

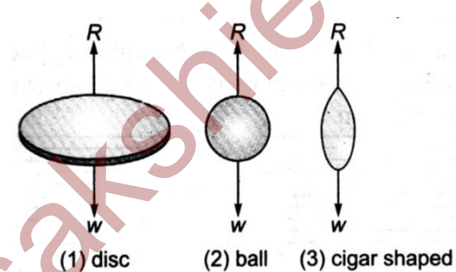
23. Two equal drops of water are falling through air with a steady velocity v. If the drops coalesced what will be the new velocity

a) $(2)^{1/3}v$ b) $(2)^{3/2}v$ c) $(2)^{2/3}v$ d) $(2)^{1/4}v$

24. A good lubricant should have

a) High viscosity b) Low viscosity c) Moderate viscosity d) High density

25. When a body falls in air, the resistance of air depends to a great extent on the shape of the body. Three different shapes are given. Identify the combination a of air resistances which truly represents the physical situation (The cross –sectional areas are the same)



a) 1 < 2 < 3 b) 2 < 3 < 1 c) 3 < 2 < 1 d) 3 < 1 < 2

26. The terminal velocity of small-sized spherical body of radius r falling vertically in a viscous liquid is given by the following proportionality

a) $1/r^2$ b) 1/r c) r d) r^2

27. The reading of a manometer fitted to a closed tap is $3.5\times10^5 Nm^2$. If the value is opened the reading of the manometer falls to $3\times10^5 Nm^{-2}$. The velocity of water is

a) $1ms^{-1}$ b) $10ms^{-1}$ c) $100ms^{-1}$ d) $0.1ms^{-1}$

28. Speed of a ball of 2cm radius in a viscous liquid is $20cms^{-1}$. Then the speed of 1cm radius of ball in the same liquid is

a) $80 cms^{-1}$ b) $40 cms^{-1}$ c) $10 cms^{-1}$ d) $5 cms^{-1}$

29. A hole is in the bottom of the tank having water. If total pressure at the bottom is 3 atm (1 atm= $10^5 Nm^{-2}$), then velocity of water flowing from hole is

a) $\sqrt{400} ms^{-1}$ b) $\sqrt{600} ms^{-1}$ c) $\sqrt{60} ms^{-1}$ d) None of these

2006

30. According to Bernoulli's equation $\frac{p}{\rho g} + h + \frac{1}{2}\frac{v^2}{g} = \text{constant}$. The terms, A, B and C are generally called respectively

a) Gravitational Head, Pressure Head and Velocity Head

b) Gravity, Gravitational Head and Velocity Head

c) Pressure Head, Gravitational Head and Velocity Head

d) Gravity, Pressure and Velocity Head

31. Assertion (A): Use of ball bearing, between two moving parts of machine is common practice.

Reason (R): Ball bearing, reduce vibrations and provide good stability.

a) Both assertion and reason are true and reason is the correct explanation of assertion.

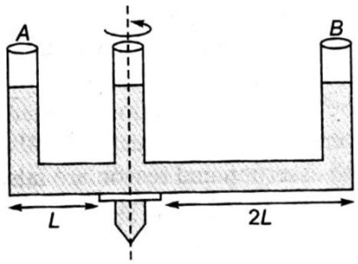
b) Both assertion and reason are true but reason is not the correct explanation of assertion.

c) Assertion is true but reason is false.

d) Both assertion and reason are false.

2005

32. A given shaped glass tube having uniform cross-section is filled with water and is mounted on a rotatable shaft as shown in figure. If the tube is rotated with a constant angular velocity ω, then



a) Water levels in both sections A and B go up

b) Water level in section A goes up and that in B comes down

c) Water level in section A comes down and that in B it goes up

d) Water levels remain same in both sections

33. Assertion (A): For Reynolds's number $R_e > 2000$, the flow of fluid is turbulent.

Reason (R): Inertial forces are dominant compared to the viscous forces at such high Reynolds's numbers.

a) Both assertion and reason are true and reason is the correct explanation of assertion.

b) Both assertion and reason are true but reason is not the correct explanation of assertion.

c) Assertion is true but reason is false.

d) Both assertion and reason are false.

34. A container with square base of side a, is filled up to a height H with a liquid. A hole is made a depth h from then free surface of water. With what acceleration the container must be accelerated, so that the water does not come out

a) g b) $\frac{g}{2}$ c) $\frac{2gH}{2}$ d) $\frac{2gH}{a}$

2004

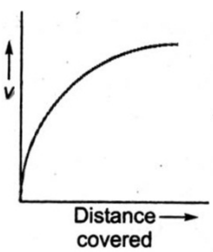
35. In old age arteries carrying blood in the human body become arrow resulting in an increase in the blood pressure. This follows from

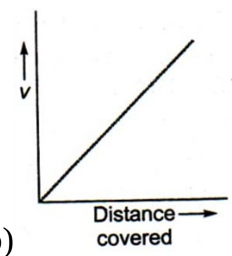
a) Pascal's law b) Stoke's law

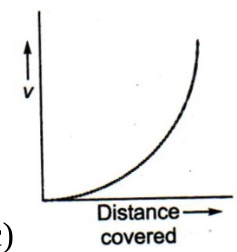
c) Bernoulli's principle d) Archimedes principle

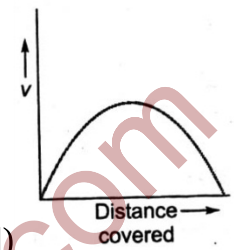
2003

36. A lead shot of a 1mm diameter falls through a long column of glycerine. The variation of its velocity v with distance covered is represented by

a) 

b) 

c) 

d) 

Surface Tension and Surfaces Energy

2004

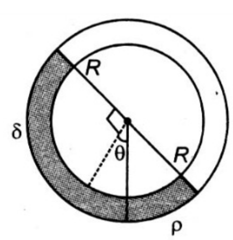
37. Calculate the force required to separate the glass plate of area $10^{-2} m^2$ with a film of water 0.05mm thick (surface tension of water is $10^{-2} m^2$)

a) 25N b) 20N c) 14N d) 28N

Pressure Difference

2010

38. A uniform long tube is bent into a circle of radius R and it lies in vertical plane. Two liquids of same volume but densities ρ and δ fill half the tube the angle θ is



a) $\tan^{-1}\left(\frac{\rho-\delta}{\rho+\delta}\right)$ b) $\tan^{-1}\left(\frac{\rho}{\delta}\right)$ c) $\tan^{-1}\left(\frac{\delta}{\rho}\right)$ d) $\tan^{-1}\left(\frac{\rho+\delta}{\rho-\delta}\right)$

2008

39. Two soap bubbles have radii in the ratio of 2: 1. What is the ratio of excess pressures inside them?

a) 1 :2 b) 1 : 4 c) 2 : 1 d) 4 : 1

40. A water drop is divided into 8 equal droplets. The pressure difference between the inner and outer side of the big drop will be

a) Same as for smaller droplet b) $\frac{1}{2}$ of that for smaller droplet

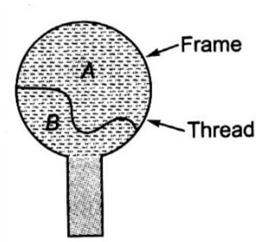
c) $\frac{1}{4}$ of that for smaller droplet d) Twice that for smaller droplet

41. Find the difference of air pressure between the inside and outside of a soap bubble 5 mm in diameter, if the surface tension is $1.6 Nm^{-1}$

a) $2560 Nm^{-2}$ b) $3720 Nm^{-2}$ c) $1208 Nm^{-2}$ d) $10132 Nm^{-2}$

2004

42. A thread is tied slightly loose to a wire frame as in figure and the frame is dipped into a soap solution and taken out. The frame is completely covered with the film. When the portion A is punctured with a pin, the thread



a) Becomes concave towards A

b) Becomes convex towards A

c) Either (a) or (b) depending on the position of A with respect to B

d) Remains in the initial position

2003

43. If the radius soap bubble is four times that of another, then the ratio of their pressure will be

a) 1 :4 b) 4 : 1 c) 16 : 1 d) 1 : 16

Capillarity

2007

44. If the length of tube is less and cannot accommodate the maximum rise of liquid, then

a) Liquid will form fountain

b) Liquid will not rise

c) The meniscus will itself so that the water does not spill

d) None of the above

2004

45. What is the shape when a non-wetting liquid is placed in a capillary tube?

a) Concave upwards b) Convex upwards

c) Concave downwards d) Convex downwards

46. In a capillary tube, water rises to 3mm. The height of water that will rise in another capillary tube having one-third radius of the first is

a) 1mm b) 3mm c) 6mm d) 9mm

Key

1) **d**	2) **c**	3) **b**	4) **c**	5) **d**	6) **a**	7) **c**	8) **b**	9) **b**	10) **a**
11) **c**	12) **b**	13) **b**	14) **c**	15) **b**	16) **c**	17) **c**	18) **a**	19) **b**	20) **b**
21) **c**	22) **b**	23) **b**	24) **a**	25) **c**	26) **d**	27) **b**	28) **d**	29) **a**	
30) **c**	31) **c**	32) **d**	33) **a**	34) **a**	35) **c**	36) **a**	37) **d**	38) **a**	39) **a**
40) **b**	41) **a**	42) **c**	43) **b**	44) **c**	45) **b**	46) **d**			

Hints

Pressure and Density

1. $V\sigma g = 0.6V\sigma_1 g$ and $V\sigma g = 0.4V\sigma_2 g$

$1 = \frac{0.6\sigma_1}{0.4\sigma_2}$

$\frac{\sigma_2}{\sigma_1} = \frac{6}{4} = \frac{3}{2}$ = 1.5

2. Force exerted by the liquid on the base of the vessel is F = mg

But, $m_A = m_B = m_C$

$\therefore F_A = F_B = F_C$

4. Pressure difference between lungs of student and atmospheric = (760 – 750) mm of Hg

, hdg = 10 mm of Hg = 1cm of Hg

Or h x 1 = 1 x 13.6

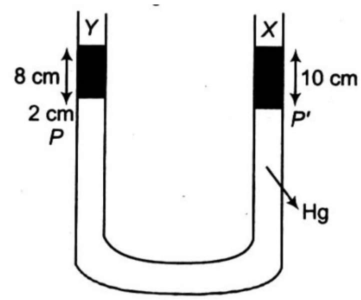
$\therefore h = 13.6cm$

5. p = hdg

i.e., the pressure depends on the height of liquid column not on its size, so pressure at the bottom of A and B is same.

Pascal's Law and Archimedes' Principle

6. $$8\times\rho_Y\times g+2\times\rho_{Hg}\times g=10\times\rho_X\times g$$



$$\therefore 8\rho_Y+2\times 13.6=10\times 3.36$$

Or $\rho_r=\dfrac{33.6-27.2}{8}$ = 0.8 g/cc

9. Let l = side of the cube

x = side of cube immersed in liquid

l – x = side of cube immersed in liquid

According to law of floating

$l^3\times 0.9\times 10^3\times g=(l^2\times x)\times 1000g+l^2(l-x)\times 0.7\times 10^3 g$

$l\times 0.9=x+(l-x)\times 0.7$

Or $0.3x=0.2l$

Or $\dfrac{x}{l}=\dfrac{2}{3}$

11. In water weight of body = weight of water displaced $=\dfrac{2}{3}V\times 1\times g$

In another liquid, weight of body $=\dfrac{1}{4}\times V\times\rho\times g$

$\therefore \dfrac{2}{3}Vg=\dfrac{1}{4}V\rho g$

Or $\rho=\dfrac{8}{3}gcc^{-1}$

13. Weight of candle = weight of liquid displaced

i.e., $V\rho g=V'\rho' g$

Or $\left(\pi \frac{d^2}{4} \times 2L\right)\rho = \left(\pi \frac{d^2}{4} L\right)\rho'$ or $\frac{\rho}{\rho'} = \frac{1}{2}$

Since, candled is burning at the rate of 2cm per hour, then after an hour it will remain 2L – 2 cm

$\therefore (2L-2)\rho = (L-x)\rho'$

Or $\frac{\rho}{\rho'} = \frac{L-x}{2(L-1)}$

So, $\frac{1}{2} = \frac{L-x}{2(L-1)}$

Or L – 1 = L – X

Or x = 1cm

Thus, it falls at the rate of $1 \ cm\, h^{-1}$

Fluid Flow

15. If A_0 is the area of orifice at the bottom below the free surface and A that of vessel, time t taken to be emptied the tank

$$t = \frac{A}{A_0}\sqrt{\frac{2H}{g}}$$

$$\therefore \frac{t_1}{t_2} = \sqrt{\frac{H_1}{H_2}}$$

$$\Rightarrow \frac{t}{t_2} = \sqrt{\frac{H_1}{H_2}}$$

$$\Rightarrow \frac{t}{t_2} = \sqrt{\frac{H_2}{H_1/2}}$$

$$\Rightarrow \frac{t}{t_2} = \sqrt{2}$$

$$\therefore t_2 = \frac{t}{\sqrt{2}} = \frac{10}{\sqrt{2}} \approx 7\,\text{min}$$

16. Terminal velocity $v=\frac{2}{9}\frac{r^2\rho g}{\eta}$

$$\Rightarrow \eta=\frac{2}{9}.\frac{r^2\rho g}{v}=\frac{2}{9}\frac{(1\times10^{-2})^2\times(1.5\times10^3)\times9.8}{0.25\times10^{-2}}=130Pa-s$$

17. $v_T-=\frac{2r^2(\rho-\sigma)g}{9\eta}$

Where $\rho=$ density of substance of body and

$\sigma=$Density of liquid

$$\frac{v_T(Ag)}{v_T(Gold)}=\frac{\rho_{Ag}-\sigma_l}{\rho_{glod}-\sigma_l}$$

$$\Rightarrow v_T(Ag)=\frac{10.5-1.5}{19.5-1.5}\times0.2=\frac{9}{18}\times0.2=0.1ms^{-1}$$

18. $\Rightarrow V=\frac{av}{A}$

$$p+\rho gh+\frac{1}{2}\rho v^2=p+0+\frac{1}{2}\rho v^2$$

$$\Rightarrow v^2=\frac{2gh}{1-\left(\frac{a}{A}\right)^2}=\frac{2\times10\times(3=0.525)}{1-(0.1)^2}=50(m/s)^2$$

19. Pressure of liquid column $=h\rho g$

$p=0.4\times900\times10Nm^{-2}$

Force on the base = p x area $=p\times2\times10^{-3}m^2=0.4\times900\times10\times2\times10^{-3}N$ = 7.2N

21. $A_1v_1=A_2v_2+A_3v_3$

$\therefore 0.2\times4=0.2\times2+0.4v_3$

Or $0.4v_3=0.8-0.4=0.4$

Or $v_3=1ms^{-1}$

22. $V=\frac{\pi pr^4}{8\eta l}$

$\therefore V\propto r^4$

$$\Rightarrow \frac{V_2}{V_1} = \left(\frac{r_2}{r_1}\right)^4$$

$$\therefore V_2 = V_1\left(\frac{110}{100}\right)^4 = V_1(1.1)^4$$

= 1.46441V

$$\therefore \frac{\Delta V}{V} = \frac{V_2 - V_1}{V} = \frac{1.4641V - V}{V} = 0.46 \text{ or } 46\%$$

23. $v = \frac{2}{9}\frac{r^2(\rho-\sigma)g}{\eta}$

$$R = (2)^{1/3} r$$

$$v' = \frac{2}{9}\left[\frac{(2^{1/3}r)^2(\rho-\sigma)g}{\eta}\right]$$

$$\frac{v'}{v} = (2)^{2/3} \text{ or } v' = (2)^{2/3} v$$

26. $v = \frac{2r^2(\rho-\sigma)g}{9\eta}$

So, $v \propto r^2$

27. From Bernoulli's theorem,

$$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$$

$$\Rightarrow \frac{1}{2}\rho v_2^2 = (p_1 - p_2) + \frac{1}{2}\rho v_1^2$$

$$= (p_1 - p_2) \qquad (\because v_1 = 0)$$

$$\Rightarrow v_2 = \sqrt{\frac{2(p_1 - p_2)}{\rho}}$$

$$\Rightarrow v_2 = \sqrt{\frac{2(3.5\times10^5 - 3\times10^5)}{10^3}}$$

$$\Rightarrow v_2 = 10 ms^{-1}$$

28. $v = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$

$\Rightarrow v \propto r^2$

Here $v_1 = 20cms^{-1}$, $r_1 = 2cm$, $r_2 = 1cm$

$\therefore \frac{v_1}{v_2} = \frac{20}{r_2^2} = \frac{(2)^2}{(1)^2}$

$\Rightarrow v_2 = 20/4 = 5cms^{-1}$

29. Let height of water column in the tank be h.

Total pressure (p) = atmospheric pressure (p_0) + pressure

Due to water column in tank (p')

$\therefore p' = p - p_0 = 3 - 1 = 2atm$

Or $h\rho g = 2\times10^5$

Or $h\times10^3\times10 = 2\times10^5$

Or h = 20m

Velocity of efflux is

$v = \sqrt{2gh} = \sqrt{2\times10\times20} = \sqrt{400}ms^{-1}$

30. $p + \rho gh + \frac{1}{2}\rho v^2 = constant$

Dividing this expression by ρg, we have

$\frac{p}{\rho g} + \frac{v^2}{2g} + h =$ Constant

In this expression $\frac{p}{\rho g}$ is called the pressure head $\frac{v^2}{2g}$ the velocity head and h the gravitational head

Surface Tension and Surface Energy

37. $F = \frac{2TA}{d}$

$A = 10^{-2} m^2$

d = 0.05 mm $= 0.05 \times 10^{-3} m$

$\therefore F = \frac{2 \times 70 \times 10^{-3} \times 10^{-2}}{0.05 \times 10^{-3}} = 28N$

Pressure Difference

38. $\delta g R(\cos\theta + \sin\theta) = \rho g R(\cos\theta - \sin\theta)$

$= \delta\cos\theta + \delta\sin\theta = \rho\cos\theta - \rho\sin\theta$

$\Rightarrow \sin\theta(\delta + \rho) = \cos\theta(\rho - \delta)$

$\Rightarrow \tan\theta = \frac{\rho - \delta}{\rho + \delta}$

39. $p = \frac{4T}{r}$

$\frac{p_1}{p_2} = \frac{4T / r_1}{4T / r_2} = \frac{r_2}{r_1}$

$\frac{p_1}{p_2} = \frac{1}{2}$

40. Volume of big drop = volume of 8 droplets

$\frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$

$\therefore r = \frac{R}{2}$

For smaller drop

$\Delta p_s = \frac{2T}{r} = \frac{2T}{R/2} = \frac{4T}{R}$

For bigger drop

$\Delta p_s = \frac{2T}{R} = \frac{1}{2}\Delta p_s$

41. The excess pressure p of bubble in air is given by

$$p = \frac{4T}{R} = \frac{4 \times 1.6}{2.5 \times 10^{-3}} = 2560 Nm^{-2}$$

43. Radius of first bubble $r_1 = R$

Radius of second bubble $r_2 = 4R$

The pressure of the soap bubble is

$$p = \frac{4T}{R}$$

$$\Rightarrow p \propto \frac{1}{R}$$

Hence, $\frac{p_1}{p_2} = \frac{R_2}{R_1} = \frac{4R}{R} = 4:1$

$$p_1 : p_2 = 4:1$$

Angle of Contact and Capillarity

46. $h = \frac{2T \cos\theta}{r \rho g}$

$$\Rightarrow h \propto \frac{1}{r}$$

$$h_1 = 3mm, \; r_2 = \frac{r_1}{3}$$

$$\therefore \frac{h_1}{h_2} = \frac{r_2}{r_1}$$

$$\Rightarrow \frac{3}{h_2} = \frac{1}{3}$$

$$\Rightarrow h_2 = 9mm$$