CBSE

MECHANICAL PROPERTIES OF FLUIDS WS 1

Class 11 - Physics

Section A

1. A cylindrical jar of cross-sectional area 0.01 m^2 is filled with water to a height of 50 cm. It carries a tight-fitting piston of negligible mass. What is the pressure at the bottom of the jar when the mass of 1 kg is placed on the piston? Take g = $10ms^{-2}$. **[1]**

   a) 6000 Pa
   b) 4000 Pa
   c) 2000 Pa
   d) 5000 Pa

2. The specific gravity of a material is: **[1]**

   a) the ratio of its density to the density of water
   b) the ratio of its mass to the density of water
   c) the ratio of its mass to the mass of water
   d) the ratio of its volume to the density of water

3. Which of the following works on Pascal's law? **[1]**

   a) Venturimeter
   b) Aneroid barometer
   c) Sprayer
   d) Hydraulic lift

4. Hydraulic press is based on: **[1]**

   a) Bernoulli's equation
   b) Reynold's law
   c) Pascal's law
   d) Archimedes' principle

5. The pressure at a depth of h in a fluid of density ρ at a place where the acceleration due to gravity is g and the pressure at h = 0 is p_0 is given by: **[1]**

   a) $p = p_0 + \rho gh$
   b) $p = p_0 + 2\rho gh$
   c) $p = \rho gh$
   d) $p = p_0 + 3\rho gh$

6. **Assertion:** The size of a hydrogen balloon increases as it rises in air. **[1]**
   Reason: The material of the balloon can be easily stretched.

   a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
   b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
   c) Assertion is correct statement but reason is wrong statement.
   d) Assertion is wrong statement but reason is correct statement.

7. **State True or False:** **[1]**
   (a) We can use water instead of mercury in a barometer. **[1]**

8. **Fill in the blanks:** **[1]**
   (a) The pressure exerted by a liquid column at rest is _____ to the height of the liquid column and **[1]**

density of the liquid.

9. There is a small bubble at one end and bigger bubble at other end of a rod. What will happen? **[1]**

a) smaller will grow until they collapse
b) remain in equilibrium
c) bigger will grow until they collapse
d) Medium will grow until they collapse

10. According to Pascal's law for transmission of fluid pressure, external pressure applied on any part of a fluid contained in a vessel is _____ in all directions. **[1]**

a) transmitted and increased
b) transmitted undiminished and equally
c) not transmitted
d) transmitted and decreased

11. Which one of the following statements is correct for fluid passing through the narrow part of the non-uniform pipe? **[1]**

a) its velocity decreases but its pressure increases
b) its velocity and pressure both increase
c) its velocity increases but its pressure decreases
d) its velocity and pressure both decrease

12. Two non-mixing liquids. of densities ρ and $n\rho(n > 1)$ are put in a container. The height of each liquid is h. A solid cylinder of length L and density d is put in this container. The cylinder floats with its axis vertical and length $pL(p < 1)$ in the denser liquid. The density of d is equal to **[1]**

a) $[2 + (n - 1)p]\rho$
b) $[1 + (n + 1)p]\rho$
c) $[1 + (n - 1)p]\rho$
d) $[2 + (n + 1)p]\rho$

13. State the principle of working of a hydraulic press. **[1]**

14. A wooden block is on the bottom of tank when water is poured in. The contact between the block and the tank is so good that no water gets between them. Is there a buoyant force on the block? **[1]**

15. Does the atmospheric pressure vary with the height above the earth's surface? **[1]**

16. What is one torr of pressure? **[1]**

17. In case of stable equilibrium, should the meta-centre be above or below the centre of gravity of the body? **[1]**

Section B

18. The density of the atmosphere at sea level is 1.29 kg/m^3. Assume that it does not change with altitude. Then how high would the atmosphere extend? **[2]**

19. A piece of iron floats in mercury. Given that the density of iron is 7.8×10^3 kg m^{-3} and that of mercury is 13.6×10^3 kgm^{-3}, calculate the fraction of the volume of iron piece that remains outside the mercury. **[2]**

20. The cross-sectional area of water pipe entering the basement is $4 \times 10^{-4} m^2$. The pressure at this point is 3×10^5 Nm^{-2} and the speed of water is 2 ms^{-1}. This pipe tapers to a cross-sectional area of $2 \times 10^{-4} m^2$ when it reaches the second floor 8 m above. Calculate the speed and pressure at the second floor. **[2]**

21. Calculate the pressure at a depth of 10 m in an Ocean. The density of sea water is 1030 kg/m^3. The atmospheric pressure is 1.01×10^5 pa. **[2]**

22. Consider a spring having spring constant of 81.75 N/m of pressure measuring device. A force acting on the piston compresses the spring downward and the area of the piston is $3m^2$. Find out the compression in the spring, if the upthrust force exerted by the fluid on the piston is 12 N. **[2]**

23. Atmospheric pressure is nearly 100 kPa. How large the force does the air in a room exert on the inside of a window pan that is 40 cm $\times$ 80 cm? **[2]**

24. State the angle of contact and on what values do the angle of contact depends? **[2]**

25. In a mercury barometer, at sea level, the normal pressure of the air (one atmosphere) acting on the mercury in the dish supports a 76 cm column of mercury in a closed tube. If you go up in the air, until the density has fallen to half its sea level value, what height of mercury column would you expect? **[2]**

26. Calculate the total pressure inside a spherical bubble of radius 0.2 mm formed inside water at a depth of 10 cm. Surface tension of water at a depth of 10 cm is 70 dyne cm^{-1}, barometric pressure is 76 cm, density of mercury is 13.6 g cm^{-3} and g = 980 cms^{-2}. **[2]**

27. What is the pressure on a swimmer 10 m below the surface of a lake? **[2]**

28. A copper cube of mass 0.50 kg is weighed in water. The mass comes out to be 0.40 kg. Is the cube hollower solid? Given density of copper = 8.96 $\times$ 10^3 kg m^{-3} and density of water = 10^3 kgm^{-3}. **[2]**

29. The average mass that must be lifted by a hydraulic press is 80 kg. If the radius of the larger piston is five times that of the smaller piston, what is the minimum force that must be applied? **[2]**

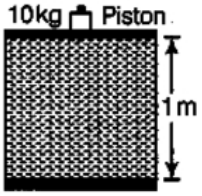
30. A cube of wood floating in water supports a 200 g mass at the centre of its top face. When the mass is removed, the mass rises by 2 cm Determine the volume of cube. **[2]**

31. At what depth in an ocean will a bubble of air have one - fourth volume, it will have on reaching the surface? Given Atmospheric Pressure = 76 cm of Hg and density of Hg = 13.6 g/cc? **[2]**

32. Why is it painful to walk barefooted on a road covered with pebbles having sharp edges? **[2]**

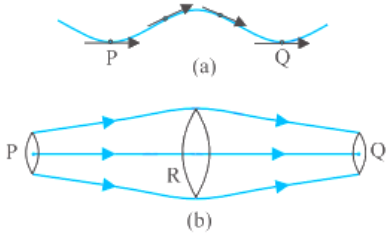
33. A cubical block of wood 10.0 cm on a side floats at the interface between oil and water, with its lower surface horizontal and 4.0 cm below the interface. What is the mass of the block? The density of the oil is 0.6 g cm^{-3}. **[2]**

34. A container of area 0.02 m^2 is filled with water. Find the pressure at the bottom of the container if a weight is placed on the piston, (as shown in the figure). **[2]**



35. Atmospheric pressure at a height of about 6 km decreases to nearly half of its value at the sea level, though the height of the atmosphere is more than 100 km. Why? **[2]**

36. In a car lift compressed air exerts a force F_1 on a small piston having a radius of 5.0 cm. This pressure is transmitted to a second piston of radius 15 cm fig). If the mass of the car to be lifted is 1350 kg, calculate F_1. What is the pressure necessary to accomplish this task? (g = 9.8 ms^{-2}). **[2]**



37. Explain why : **[2]**

i. A balloon filled with helium does not rise in air indefinitely but halts after a certain height (Neglect winds).

ii. The force required by a man to raise his limbs immersed in water is smaller than the force for the same movement in air.

38. The area of the smaller piston of a hydraulic press is 1 cm^2 and that of larger piston is 22 cm^2. How much weight can be raised on the larger piston by a 200 kg f exerted on the smaller piston? **[2]**

39. Show that if two capillaries of radii r_1 and r_2 having lengths l_1 and l_2 respectively are set in series, the rate of flow Q is given by $Q = \frac{\pi p}{8\eta}\left[\frac{l_1}{r_1^4} + \frac{l_2}{r_2^4}\right]^{-1}$ where p is the pressure difference across the arrangement and q is the coefficient of viscosity of the liquid. **[2]**

40. Express standard atmospheric pressure in **[2]**

i. bars and

ii. torr.

41. A block weighs 15 N in air. It weighs 12 N when immersed in water. When immersed in another liquid, it weighs 13 N. Calculate the relative density (specific gravity) of **[2]**

i. the block and

ii. the other liquid.

42. A 50 kg girl wearing high heels shoes balances on a single heel. The heel is circular with a diameter of 1.0 cm. What is the pressure exerted on the horizontal floor? **[2]**

Section C

43. Glycerine flows steadily through a horizontal tube of length 1.5 m and radius 1.0 cm. If the amount of glycerine collected per second at one end is $4.0 \times 10^{-3} \mathrm{kgs}^{-1}$, what is the pressure difference between the two ends of the tube? (Density of glycerine = $1.3 \times 10^3 \mathrm{kgm}^{-3}$ and viscosity of glycerine = 0.83 Pa s). [You may also like to check if the assumption of laminar flow in the tube is correct]. **[3]**

44. At a depth of 1000 m in an ocean **[3]**

a. what is the absolute pressure?

b. What is the gauge pressure?

c. Find the force acting on the window of area 20 cm $\times$ 20 cm of a submarine at this depth, the interior of which is maintained at sea level atmospheric pressure.

(The density of sea water is 1.03 $\times$ 10^3 kg m^{-3}, g = 10 ms^{-2}.)

45. A piece of ice with a stone frozen in it floats on water taken in a beaker. Will the level of water increase or decrease or remain the same when the ice melts completely? **[3]**

46. Explain why? **[3]**

a. The blood pressure in humans is greater at the feet than the brain.

b. Atmospheric pressure at a height of about 6 km decreases to nearly half its value at the sea level through the height of the atmosphere is more than 100 km.

c. Hydrostatic pressure is a scalar quantity even though the pressure is force divided by area.

47. A rectangular tank is 10 m long, 5 m broad and 3 m high. It is filled to the rim with water of density 10^3 kg m^{-3}. Calculate the thrust at the bottom and walls of the tank due to hydrostatic pressure. Take g = 9.8 ms^{-2}. **[3]**

48. A U-tube contains water and methylated spirit separated by mercury. The mercury columns in the two arms are in level with 10.0 cm of water in one arm and 12.5 cm of spirit in the other. What is the specific gravity of spirit? **[3]**

49. A vertical off-shore structure is built to withstand a maximum stress of 10^9 Pa. Is the structure suitable for **[3]**

putting up on top of an oil well in the ocean? Take the depth of the ocean to be roughly 3 km, and ignore ocean currents.

50. A vessel filled with water is kept on a weighing pan and the scale adjusted to zero. A block of mass M and ρ density is suspended by a mass less spring of spring constant k. This block is submerged inside into the water in the vessel. What is the reading of the scale? **[3]**

51. State Pascal's law. Explain the working of a hydraulic lift. **[3]**

52. Water is flowing through two horizontal pipes of different diameters which are connected together. In the first pipe, the speed of water is 4 ms^{-1} and the pressure is 2.0×10^4 Nm^{-2}. Calculate the speed and pressure of water in the second pipe. The diameters of the pipes are 3 cm and 6 cm respectively. **[3]**

53. In Millikan's oil drop experiment, what is the terminal speed of an uncharged drop of radius 2.0×10^{-5}m and density 1.2×10^3 kgm^{-3}? Take the viscosity of air at the temperature of the experiment to be 1.8×10^{-5} Pa s. How much is the viscous force on the drop at that speed? Neglect buoyancy of the drop due to air. **[3]**

54. What is the pressure inside the drop of mercury of radius 3.00 mm at room temperature? Surface tension of mercury at that temperature (20°C) is 4.65×10^{-1} Nm^{-1}. The atmospheric pressure is 1.01×10^5 Pa. Also give the excess pressure inside the drop. **[3]**

55. Briefly discuss how Pascal's law is affected by gravity. Hence obtain Pascal's law of transmission of pressure. **[3]**

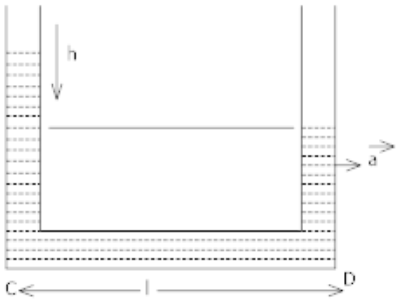
56. The manual of a car instructs the owner to inflate the tyres to a pressure of 200 kPa. **[3]**

    i. What is the recommended gauge pressure?

    ii. What is the recommended absolute pressure?

    iii. If after the required inflation of the tyres, the car is driven to a mountain peak where the atmospheric pressure is 10% below that at sea level, what will the tyre gauge read?

57. A liquid stands at the same level in the U - tube when at rest. If A is the area of cross section of tube and g is the acceleration due to gravity, what will be the difference in height of the liquid in the two limbs when the system is given acceleration ‘a’? **[3]**



Section D

58. Glycerine flows steadily through a horizontal tube of length 1.5 m and radius 1.0 cm. If the amount of glycerine collected per second at one end is 4.0×10^{-3} kgs^{-1}, what is the pressure difference between the two ends of the tube? (Density of glycerine = $1.3 \times 10^3 kgm^{-3}$ and viscosity of glycerine = 0.83 Nsm^{-2}. **[5]**

59. Two capillary tubes AB and BC are joined end to end at B. AB is 16 cm long and of diameter 4 mm whereas BC is 4 cm long and of diameter 2 mm. The composite tube is held horizontally with A connected to a vessel of water giving a constant head of 3 cm and C is open to the air. Calculate the pressure difference between B and C. **[5]**

60. A venturi meter is 37.5 cm in diameter in mains and 15 cm diameter in the throat. The difference between the pressure of water in the mains and the throat is 23 cm of Hg. Find the discharge in litres per minute. Sp. the gravity of Hg = 13.56. **[5]**

61. State and prove the Pascal's law of transmission of fluid pressure. **[5]**

62. Two tubes A and B of lengths 100 cm and 50 cm have radii 0.1 mm and 0.2 mm respectively. If a liquid passing through the two tubes is entering A at a pressure of 80 cm of mercury and leaving B at a pressure of 76 cm of mercury, determine the pressure at the junction of A and B. **[5]**

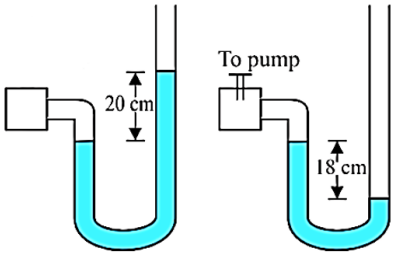
63. A manometer reads the pressure of a gas in an enclosure as shown in Fig **[5]**

a. When a pump removes some of the gas, the manometer reads as in Fig

b. The liquid used in the manometers is mercury and the atmospheric pressure is 76 cm of mercury.

i. Give the absolute and gauge pressure of the gas in the enclosure for cases (a) and (b), in units of cm of mercury.

ii. How would the levels change in case (b) if 13.6 cm of water (immiscible with mercury) are poured into the right limb of the manometer? (Ignore the small change in the volume of the gas).



64. The level of liquid in a cylindrical vessel is kept constant at 30 cm. It has three identical horizontal tubes of length 39 cm. each coming out at heights 0, 4 and 8 cm respectively. Calculate the length of a single overflow tube of the same radius as that of identical tubes which can replace the three when placed horizontally at bottom of the cylinder. **[5]**

65. The pressure difference between two points along a horizontal pipe, through which water is flowing, is 1.4 cm of mercury. If due to a non-uniform cross-section, the speed of flow of water at the point of the greater cross-section is 60 cm s^{-1}, calculate the speed at the other point. **[5]**

66. a. It is known that density ρ of air decreases with height y as **[5]**

$$\rho = \rho_0 e^{-y/y_0}$$

where ρ_o = 1.25 kg m^{-3} is the density at sea level, and y_0 is a constant. This density variation is called the law of atmospheres. Obtain this law assuming that the temperature of the atmosphere remains constant (isothermal conditions). Also, assume that the value of g remains constant.

b. A large He balloon of volume 1425 m^3 is used to lift a payload of 400 kg. Assume that the balloon maintains a constant radius as it rises. How high does it rise?

[Take y_0 = 8000 m and ρ_{He} = 0.18 kg m^{-3}].

67. Consider the hydraulic lift having small cylindrical piston and larger piston with radii 4.0 cm and 16 cm, respectively. If a truck of mass 3000 kg is placed on the larger piston, then find out the force must be applied to the small piston to lift the truck. Also find how far must the small piston move down to lift the truck through a height of 0.20 m. Assume initially these two pistons are at the same height, (take g = 10 m/s^2). **[5]**

A downward force F_1 is applied to a piston with a small area or smaller piston and a downward force with magnitude F_2 equal to the weight of the truck is applied on the larger piston.

68. Discuss the variation of fluid pressure with depth. Hence explain how is Pascal's law affected in the presence of gravity. **[5]**

69. Consider the hydraulic lift having small cylindrical piston and larger piston with radii 4.0 cm and 16 cm, **[5]**

respectively. If a truck of mass 3000 kg is placed on the larger piston, then find out the force must be applied to the small piston to lift the truck. Also find how far must the small piston move down to lift the truck through a height of 0.20 m. Assume initially these two pistons are at the same height, (take g = 10 m/s^2).

A downward force F_1 is applied to a piston with a small area or smaller piston and a downward force with magnitude F_2 equal to the weight of the truck is applied on the larger piston.

70. A drum of 30 cm radius has a capacity of 220 dm^3 of water. It contains 198 dm^3 of water and is placed on a solid block of exactly the same size as of drum. If a small hole is made at the lower end of the drum perpendicular to its length, find the horizontal range of water on the ground in the beginning. Given g = 980 cms^{-2}. **[5]**

71. Show that a pressure difference exists between the two sides of a curved liquid surface. **[5]**

72. Derive an expression for the excess pressure inside a liquid drop. **[5]**

73. A pitot tube is mounted on an aeroplane wing to measure the speed of the plane. The tube contains alcohol and shows a level difference of 40 cm What is the speed of the plane relative to air? (sp. gr. of alcohol = 0.8 and density of air = 1 kg m^{-3}). **[5]**

74. State and prove Archemedes' principle. **[5]**

75. What is meant by torr? Calculate the height of the atmosphere. **[5]**