PHYSICS

NCERT - NCERT PHYSICS(ENGLISH)

MECHANICAL PROPERTIES OF FLUIDS

Solved Example

1. The two thigh bones (femur bones) each of cross-sectional area $10cm^2$ support the upper part of a human body of mass 40 kg . Estimate

the average pressure sustained by the femurs.

$g = 10m/s^2$

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2. What is the pressure on a swimmer 10m below the surface of lake? $g = 10ms^{-2}$, atmospheric pressure = $1.01 \times 10^5 Pa$

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3. The density of the atmosphere at sea level is $1.29kg/m^3$. Assume that it does not change with altitude. Then how high would the atmosphere extend ? $g = 9.8ms^{-2}$. Atmospheric pressure $= 1.013 \times 10^5 Pa$.

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4. At a depth of 1000 m in an ocean (a) what is the absolute pressure? (b) what is the gauge pressure? (c) Find the force acting on the

window of area $20cm \times 20cm$ of a submarine at this depth, the interior of which is maintained at sea-level atmospheric pressure. The density of sea water is $1.03 \times 10^3 kgm^{-3}$, $g = 10ms^{-2}$. Atmospheric pressure = $1.01 \times 10^5 Pa$.

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5. Two syringes of different cross-sections (without needles) filled with water are connected with a tightly fitted rubber tube

filled with water. Diameters of the smaller piston and larger piston are 1.0cm and 3.0 cm respectively.

(a) Find the force on the larger piston when a force of 10N is applied to the smaller piston.

(b) The smaller piston is paused in through 6.0 cm, much does the larger piston move out?

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6. In a car lift, compressed air exerts a force F_1 on a small piston having a radius of $0.5cm$.

This pressure is transmitted to a second piston of radius 10.0 cm . If the mass of the car to be lifted is 1350 kg. calculate F_1. What is the pressure necessary to accomplish this task?

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7. The flow of blood in a large artery of an anaeshetized dog is diverted through a venturimeter. The wider part of the meter has a cross sectional area equal to that of the artery i.e. $8mm^2$. The narrower parts has an

are $4mm^2$. The pressure dorp in the artery is $24Pa$. what is the speed of the blood in the artery ? Given that density of the blood = $1.06 \times 10^3 kg/m^3$

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8. A fully loaded Boeing aircraft has a mass of $3.3 \times 10^5 kg$. Its total wing area is $500m^2$. It is in level flight with a speed of $960km/h$.

(a) Estimate the pressure difference between the lower and upper surfaces of the wings

(b) Estimate the fractional increases in the speed of the air on the upper surfaces of the wing relative to the lower surface. The density of air is $1.2kg/m^3$.

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9. A metal plate of area $0.10m^2$ is connected to a $0.01kg$ mass via a string that passes over an ideal pulley (considered to be friction-less), as shown in the figure. A liquid with a film thickness of $3.0mm$ is placed between the

plate and the table. When released the plate moves to the right with a constant speed of $0.085ms^{-1}$. Find the coefficient of viscosity of the liquid.

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10. The terminal velocity of a copper ball of radius $2mm$ falling through a tank of oil at $20^{\circ}C$ is $6.5cm/s$. Find the viscosity of the oil

at $20^{\circ}C$. Density of oil is $1.5 \times 10^{3} Kg/m^{3}$, density of copper is $8.9 \times 10^{3} Kg/m^{3}$.

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11. The lower end of a capillary tube of diameter 2.0 mm is dipped 8.00cm below the surface of water in a beaker. What is the pressure required in the tube in order to blow a hemispherical bubble at its end in water? The surface tension of water at temperature of the experiments is $7.30 \times 10^{-2} Nm^{-1}$. 1

atmospheric pressure $=1.01 \times 10^5 Pa$, density of water $= 1000 kg/m^3$, $g = 9.80 ms^{-2}$. also calculate the excess pressure.

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Exercise

1. Explain why (a) the blood pressure is humans is greater at the feet than at 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 atmospheric is more than 100 km.

(c) Hydrostatic pressure is a scalar quantity even though pressure is force divided by area , and force is a vector.

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2. Explain why

(a). The angle of contact of mercury with galss is obtuse, while that of water with glass is

acute.

(b). Water on a clean glass surface tends to spread out while mercury on the same surface tends to form drops. (Put differently, water wets glass while mercury does not).

(c). Surface tension of a liquid is independent of the area of the surface

(d). Water with detergent disolved in it should have small angles of contact.

(e). A drop of liquid under no external forces is always spherical in shape.

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3. Find in the blanks using the word (s) from the test appended with each statement.

(a) Surface tension of liquid generally .....with temperatures (increase//decreases).

(b) Viscosity of gases ..... With temperature, whereas viscosity of liquids .....with temperature. (increases//decreases)/

(c) For solids with elastic modulus of rigidity, the shearing force is proportional to .....while for fluids it is proportional to ....(shear strain//rate of shear strain).

(d) For a fluid in a steady flow, from .....

(conservation of mass// Bernoulli's principle)

(e) For the model of a plane in a wind tunnel, turbulence oc curs at a ..... speed for turbulence for an actual plane (greater//smaller)/

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4. Explain why

(a). To keep a piece of paper horizontal, you should blow over, not under, it

(b). When w try to close a water tap with our

fingers, fast jets of water gush through the openings between our fingers

(c). The size of the needle of a syringe controls flow rate better than the thumb pressure exerted by a doctor while administering an injection

(d). A fluid flowing out of a small hole in a vessel results in a backward thrust on the vessel

(e). A spinning cricket ball in air does not follow a parabolic trajectory.

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5. A 50 kg. girl wearing high heel shoes balance on a single heel. The heel is circular with a diameter 1 cm. what is the pressure exerted by the heel on the horizontal floor?

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6. Torricelli's barometer used mercury. Pascal duplicated it using French wine of density $984 kgm^{-3}$. Determine the height of the wine column for normal atmospheric pressure.

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7. A vertical off-shore structure is built to withstand a a maximum stress of $10^9 Pa$. Is the structure suitabel for putting upon top of an oil well in bombay high? Take the depth of the sea to be roughly 3 km, and ignore oceam currents.

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8. A hydraulic automobile lift is designed to lift cars with a maximum mass of 300 kg. the area of cross-section of the piston carrying the load is $425cm^3$. What maximum pressure would smaller piston have to bear?

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9. A U tube contains water and methylated spirts separated by mercury columns in the two arms are in level with 10.0cm of water in

one arm and 12.5 cm of spirit in the other. What is the relative density of spirit?

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10. If 15.0 cm of water and spirit each are further poured into the respective arms of the tube, what is the difference in the levels of mercury in the two arms? (Relative density of mercury = 13.6).

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11. Can Bernoulli's equation be used to describe the flow of water through a rapid in a river? Explain.

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12. Does it matter if one uses gauge instead of absolute pressures in applying Bernoulli's equation. Explain.

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13. Glycerine flows steadily through a horizontal tube of length 1.5m and radius 1.0 cm. if the amount of glycerine collected per second at one end is $4.0 \times 10^{-3} kgs^{-1}$, what is the pressuer difference between the two ends of the tube? (density of glycerine = $1.3 \times 10^{3} kgm^{-3}$ and viscosity of glycerine = $0.83 Nsm^{-2}$).

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14. In a test experiment on a model aeroplane in a wind tunnel, the flow speeds on the upper and lower surfaces of the wing are $70ms^{-1}$ and $83ms^{-1}$ respectively. What is the lift on the wing, if its area is $2.5m^2$? Take the density of air to be $1.3kgm^{-3}$

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15. The steady flow of (non-viscous) liquid. Which of the two figure is incorrect?why?

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16. The cylinderical tube of a spray pump has a cross-section of $8.0cm^2$ one end of which has 40 fine holes each of diameter 1.0mm. If the liquid flow inside the tube is 1.5 m per minute, what is the speed of ejection of the liquid through the holes?

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17. A U-shaped wire is dipped in a soap solution, and removed. A thin soap film formed between the wire and a light slider supports a weight of $1.5 \times 10^{-2} N$ (which includes the small weigh of the slider). The length of the slider is 30cm. What is the surface tension of the film?

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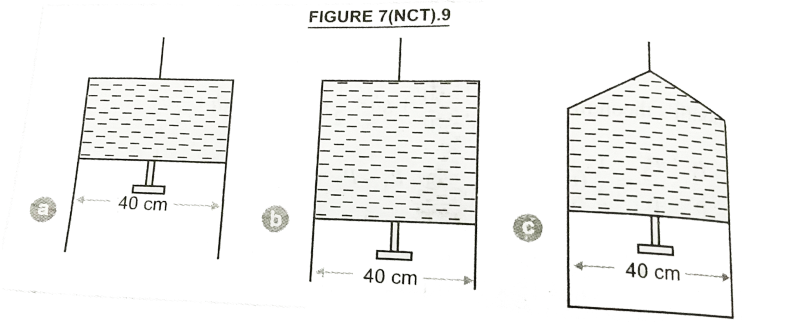
18. Fig, shown a thin film supporting a small weight = $4.5 \times 10^{-2} N$. What is the weight supported by a film of the same liquid at the same temperature in fig. explain your answer physically.



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19. What is the pressure inside a drop of mercury of radius 3.0mm at room temperature? Surface tension of mercury at that temperature $(20^{\circ}C)$ is $4.65 \times 10^{-1} Nm^{-1}$. The atmospheric pressure is $1.01 \times 10^{5} Pa$. Also give the excess pressure inside the drop.

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20. What is the excess pressure inside a bubble of soap solution of radius 5.00mm,

given that the surface tension of soap solution at the temperature $(20^{\circ}C)$ is $2.50 \times 10^{-2} Nm^{-1}$? If an air bubble of the same dimension were formed at a depth of 40.0 cm inside a container containing the soap solution (of relative density 1.20), what would be the pressure inside the bubble? (1atm. is $1.01 \times 10^{5} Pa$).

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21. A tank with a square base of area $1.0m^2$ is divided by a vertical parition in the middle. The bottom of the partition has a small hinged door of area $20cm^2$. The tank is filled with water and an acid (of relative density 1.7) in the other, both to a height of $4.0m$. Compute to force necessary the force nec cessary to keep the door closed.

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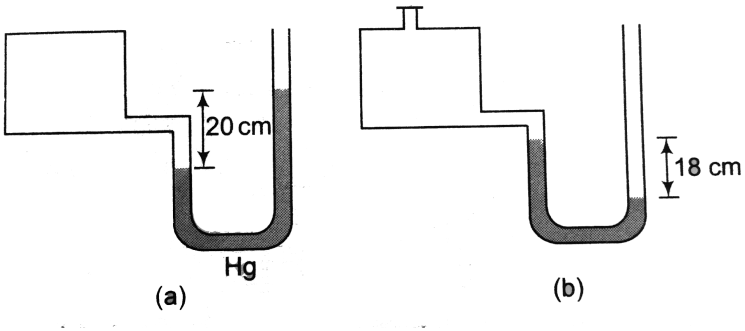
22. A manometer reads the pressure of a gas in a enclosure as shown in figure(a) When some of the gas is removed by a pump, the manometer reads as in (b). The liquid used in the manometers is mercury and the atmospheric pressure is $76cm$ of mercury.



(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 level change in case (b) if $13.6cm$ of water are poured into the right limb of the manometer?

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23. Two vessels have the same base area but differnent shapes. The first vessel takes twice the vloume of water that the second vessel requires to fill up to a paricular common height . Is the force exerted by water on the

base of the vessel the same in the two case? If so, why do the vessels filled with water to that same height give different reading on a weighting scale ?

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24. During blood transfusion the needle is inserted in a vein where the gauge pressure is $2000Pa$. At what height must the blood container be placed so that blood may just

enter the vein? Density of whole blood = $1.06 \times 10^3 Kg/m^3$.

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25. In deriving Bernoulli's equation , we equated the workdone on the fluid in the tube to its change in the potential and kinetic energy (a) How does the pressure change as the fluid moves along the tube if dissipative forces are present ? (b) Do the dissipative

forces becomes more important as the fluid velocity increase? Discuss qualitatively.

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26. (a) What is the largest average velocity of blood flow in an artery of radius $2 \times 10^{-3} m$ if the flow must remian laminar?

(b) What is the corresponding flow rate? Take viscosity of blood to be $2.084 \times 10^{-3} Pa - s$. Density of blood is $1.06 \times 10^{3} kg / m^{3}$.

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27. A plane is in level flight at constant speed and each of its wings has an area of $25m^2$. If the speed of the air is $180km/h$ over the upper wing surface, determine the plane's mass . (Take air density to be $1kg/m^3$). $g = 9.8m/s^2$.

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28. In Millikan's oil drop experiment, what is the terminal speed of a speed of a drop of

radius $2.0 \times 10^5 m$ and density $1.2 \times 10^3 m^{-3}$? Take the viscosity of air at the temperature of the experimental to be $1.8 \times 10^{-5} Nsm^2$. How much is the viscous force on the drop at that speed? Neglect buoyancy of the drop due to air.

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29. Mercury has an angle of contact equal to 140° with soda lime galss. A narrow tube of radius $1.00mm$ made of this glass is dipped in

a through containing mercury. By what amount does the mercury dip down in the tube relative to the mercury surface outside? Surface tension of mercury at the temperature of the experiment is $0.465Nm^{-1}$. Density of mercury = $13.6 \times 10^3 kgm^{-3}$.

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30. Two narrow bores of diameters 3.0mm and 6.0 mm are joined together to form a U-shaped tube open at both ends. If th U-tube

contains water, what is the difference in its levels in the two limbs of the tube? Surface tension of water at the temperature of the experiment is $7.3 \times 10^{-2} Nm^{-1}$. Take the angle of contact to be zero. and density of water to be $1.0 \times 10^{3} kg/m^{3}$.

$(g = 9.8 ms^{-2})$

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31. (a). It is known that density ρ of air decreases with height y as

$\rho = \rho_0 e^{-y/y(_o)}$ ltb rgt where $p_o = 1.25 kgm^{-3}$ is the density at sea level, and y_o is a constant. This density variation is called the law of atmospheres. Obtain this law assuming that the temperature of atmosphere remains a 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 constant radius as it rises. How high does it rise?

[take $y_o = 8000 m$ and $\rho_{He} = 0.18 kgm^{-3}$]

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