PHYSICS

BOOKS - MODERN PUBLICATION

Surface Tension

Example

1. Calculate the work done in blowing up a soap bubble from an initial surface area of $0.50cm^2$ to a final surface area of $1.10cm^2$. The surface tension of soap solution is $30dy \neq cm^{-1}$

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2. What is the pressure inside the drop of mercury of radius 3.00 mm at room temperature ? Surface tension of mercury at that temperature (

$20^\circ C$) 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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3. Mercury has an angle of contact equal to 140° with soda lime glass. A narrow tube of radius 1.00 mm made of this glass is dipped in a trough containing mercury. By what amount does the mercury dip down in the tube relative to the liquid surface outside ? Surface tension of mercury at the temperature of the experiment is 0.465 Nm^{-1}. Density of mercury = $13.6 \times 10^3 kgm^{-3}$.

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

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5. A wire ring of 3 cm. radius is rested on the surface of a liquid and then raised. The pull required is 3.03 g more before the film breaks than it is after. Find the surface tension of the liquid.

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6. A liquid drop of Diameter 'D' breaks up into 27 tiny drops. Find the resulting change in energy.

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7. A glass tube of 1 mm diameter is dipped vertically into a container of mercury, with its lower end 3 cm below the mercury surface. What must be the gauge pressure of air in the tube to blow a hemispherical bubble at its lower end? Given that density of mercury=$13,600 kgm^{-3}$ and surface tension of mercury=$0.540 Nm^{-1}$

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8. What is the excess pressure inside a bubble of soap solution of radius 5.00 mm,given that the surface tension of soap solution at the temperature (20^@C) is 2.50xx 10 2 N in 1 ? If an air bubble of the same dimension were formed at 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 ? (1 atmospheric pressure is 1.01xx 105 Pa).

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9. What will be the pressure inside a small air bubble of 0.1 mm radius situated just below the free surface of water ? Surface tension is 72 dyne cm^{-1} and atmospheric pressure is 1.013×10^6 dyne cm^{-2}.

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10. A small hollow sphere which has a small hole in it is immersed in water to a depth 40 cm before any water penetrates into it. If the surface tension of water is $75dy \neq cm^{-1}$, find the radius of the hole.

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11. A capillary tube whose inside radius is 0.5 mm is dipped in water of surface tension$75dy \neq cm\ -^{1}$. To what height is the water raised by the capillary action above the normal water level ? Angle of contact of water with glass is 0° and g=$980cms^{-2}$

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12. Water rises to a height of 2.94 cm capillary tube, while mercury depresses by 1.1 cm in the same tube. Find the ratio of the surface tension of mercury to that of water. Given that density of water = $10^{3}kgm^{-3}$, density of mercury = $13.6 \times 10^{3}kgm^{-3}$ angle of contact for water = 0° and angle of contact for mercury= 140°

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13. Two narrow bores of diameters 3.0 mm and 6.0 mm are joined together to form a U-tube open at both ends. If the 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 $7.3 \times 10^{-2} Nm^{-1}$'. $Takethe \angle ofcontact \rightarrow bezero$ and $densityofwater -$ 1.0xx 10^3 kg m^- 3(g = 9.8 m s^-2`) .

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14. If a number of little droplets of water, all of the same radius r, coalesce to form a single drop of radius R, show that the rise in temperature will be given by $\frac{3T}{\rho J}\left(\frac{1}{r}-\frac{1}{R}\right)$ where T is the surface tension of water and J is the mechanical equivalent of heat.

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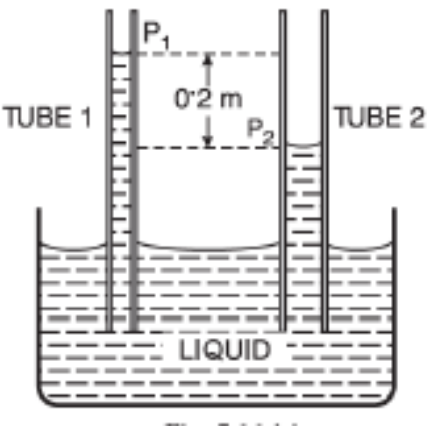
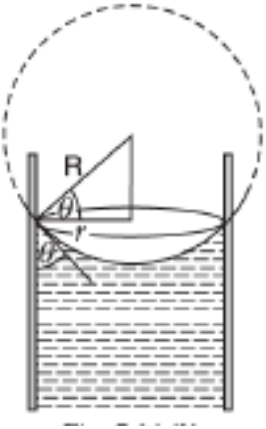
15. A barometer contains two uniform capillaries of radii $7.2 \times 10^{-4} m$ and $1.44 \times 10^{-3} m$. If the height of liquid in narrow tube is 0.2 m more than that in the wide tube, calculate the true pressure difference. Density of liquid = $10^3 kgm^{-3}$, surface tension = $72 \times 10^{-3} Nm^{-1}$ and g = $9.8 ms^{-2}$





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16. What is meant by sphere of influence of a liquid molecule ?

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17. Which part of a liquid is responsible for the phenomenon of surface tension?

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18. Why does free surface of a liquid behave like a stretched membrane ?

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19. How is surface energy related to surface tension of a liquid ?

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20. What effect does temperature have on the surface tension of a liquid ?

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21. Explain why small liquid drops are spherical in shape but big drops are flat ?

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22. Why small drop of mercury is spherical but bigger drops are oval in shape?

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23. What is the angle of contact?

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24. What are the factors on which angle of contact depends?

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25. What is the effect on the angle of contact when the temperature of a liquid is increased?

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26. Why are brick walls plastered with cement?

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27. Why does wet ink get absorbed by a blotting paper?

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28. By which phenomenon water rises from the root to the leaves of plants?

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29. In summer, cotton dress is preferable. Give reason.

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30. Antiseptics should be of low surface tension or The antiseptics used for cuts and wounds in human flesh have low surface tension. Explain, why.

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31. The addition of flux (soldering paste) to the tin makes soldering process easy. Why?

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32. The paints and lubricating oils have low surface tension. Why?

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33. What is the function of damp-proof layer?

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34. How does the ploughing of fields help in preservation of moisture in the soil?

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35. Oil is poured to calm sea waves. Explain, why.

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36. What is wetting agent?

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37. A mercury barometer always reads less than actual pressure. Why?

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38. Why the nib of a pen is split?

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39. Why smearing of glycerine over the glass window prevents rain drops from sticking to it?

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40. What makes a water-proof raincoat water proof?

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41. Teflon is coated on the surface of non-sticking pans. Explain why.

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42. On which side of a liquid surface, pressure is more?

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43. How is the rise of a liquid affected if the top of the capillary tube is closed?

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44. Air is blown into a soap bubble to increase its size. What will be the effect on the air pressure inside it?

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45. What happens to surface tension when impurity is mixed in a liquid?

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46. Why is it not possible to separate two pieces of paper joined by glue or gum? Explain

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47. It is possible to produce fairly vertical film of soap solution but not of pure water. Why

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48. Why is that molecules of a liquid near the free surface possess extra energy?

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49. In order to increase the surface area of a liquid, work has to be done. Is it against the law of conservation of energy?

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50. What shape does a liquid take, when it weighs nothing?

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51. The velocity of water in a river is less on the bank and large in the middle. Explain, why.

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52. A piece of chalk immersed into water emits bubbles in all directions. Why?

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53. The new earthen pots keep water cooler than the old ones. Why?

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54. Water wets the glass, while mercury does not. Explain, why.

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55. Mercury does not cling to glass. Why?

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56. Mercury does not cling to glass. Why?

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57. Small insects can move about on the surface of water. How?

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58. End of a glass tube becomes round on heating Explain.

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59. When sewing, Why does a person often wet the end of the thread before trying to put it through the eye of a needle?

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60. Why is it that a needle may float on clear water but will sink, when some detergent is added to water?

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61. Why water gets depressed in a glass tube whose inner surface is coated with wax?

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62. How is the rise of a liquid affected if the top of the capillary tube is closed?

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63. Why it is easer to wash clothes in hot water soap solution?

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64. It is easier to spray water in which some soap is dissolved. Explain, why.

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65. Why does a small piece of camphor dance about on the water surface ?

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66. Water rises in capillary tube, whereas mercury falls in the same tube. Explain.

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67. Sand is a drier soil than clay. Why?

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68. A 20 cm long capillary tube is dipped in water. the water rises up to 8 cm. if then there arrangement is put in a freely falling elevator, what will

be the length of water column in the capillary tube?

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69. Explain what happens when length of a tube is less than the height upto which a liquid may rise in it?

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70. Explain why oil spreads over the surface of water?

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71. A large force is required to draw apart normally two glass plates enclosing a thin water film

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72. It is difficult to make mercury ender a fine thermometer tube. explain why

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73. Water can be poured into a bottle having a narrow neck with the help of a glass rod. Explain why.

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74. How does surface tension change with temperature?

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75. What is the effect of less soluble impurities on the surface tension of a liquid.

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76. A large bubble is formed at one end of the capillary tube and a small one at the other end. which will grow at the expense of the other?

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77. What will be the pressure inside a small air bubble of 0.1 mm radius situated just below the free surface of water ? Surface tension is 72 dyne cm^{-1} and atmospheric pressure is 1.013×10^6 dyne cm^{-2}.

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78. A soap film is formed on a rectangular frame of 7 cm side dipping into a scop solution. The frame hangs from the arm of a balance. An extra weight of 0.4 gram is to be placed in the opposite pan to balance the pull on the frame. Caluclate the surface tension of the soap solution

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79. A glass plate of length 10 cm, breadth 4 cm and thickness 0.4 cm weighs 40 g in air. If it is held vertically with long side horizontal and the plate half immersed in water, what will be its apparent weight? Surface tension of water $= 70dy \neq cm^{-1}$.

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80. Calculate the work done in blowing a soap bubble from a radius of 2 cm to 3 cm, the surface tension of the soap solution is $30dy \neq cm^{-2}$

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81. Calculate the amount of energy evolved when 8 droplets of water (Surface tension 0.072 Nm^{-1}) of radius $\frac{1}{2}$ mm each combines into one.

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82. Calculate the energy spent in spraying a drop of mercury of r=1cm radius into 10^6 droplets all of the same size. If the surface tension of mercury is $32 \times 10^{-2} Nm^{-1}$

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83. Calculate the energy spent in spraying a drop of mercury of r=1cm radius into 10^6 droplets all of the same size. If the surface tension of mercury is $32 \times 10^{-2} Nm^{-1}$

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84. A film of water is formed between two straight parallel wires of length 10 cm each separated by 0.5cm If their separation is increased by 1mm while still maintaining their parallelism, how much work will have to be done (Surface tension of water $=7.2 \times 10^{-2} Nm^{-1}$)

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85. A soap bubble is blown to a diameter of 7 cm. if 36960 ergs of work is done in blowing if further find the new radius, if surface tension of the soap solution is 40 dynes/cm.

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86. What is the excess pressure inside a bubble of soap solution of radius 5.00 mm,given that the surface tension of soap solution at the temperature (20^@C) is 2.50xx 10 2 N in 1 ? If an air bubble of the same dimension were formed at 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 ? (1 atmospheric pressure is 1.01xx 105 Pa).

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87. What is the excess pressure inside a bubble of soap solution of radius 5.00 mm,given that the surface tension of soap solution at the temperature (20^@C) is 2.50xx 10 2 N in 1 ? If an air bubble of the same

dimension were formed at 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 ? (1 atmospheric pressure is 1.01xx 105 Pa).

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88. The pressure of air in a soap bubble of 0.7 cm diameter is 8 mm of water above the atmospheric pressure calculate the surface tension of soap solution.

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89. If the excess pressure inside a soap bubble of radius 1 cm is balanced by a column of oil 1.36 mm high, find the surface tension of the bubble. (specific gravity of liquid = 0.9)

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90. What will be the pressure inside a small air bubble of 0.1 mm radius situated just below the free surface of water ? Surface tension is 72 dyne cm^{-1} and atmospheric pressure is 1.013×10^6 dyne cm^{-2}.

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91. Two soap bubbles have radii in the ratio 1:2. compare the excess of pressure inside these bubbles. also compare the work done in blowing these bubbles

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92. Find the difference in excess pressure on the inside and outside of a raindrop if its diameter changes from 1.003cm to 1.002 cm by evaporation. (surface tension of rain water is $72dy \neq cm^{-1}$)

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93. calculate the height to which water at 4° rise in a capillary tube of 1 mm diameter. take g = $980 cms^{-2}$ and surface tension of water is $72 dy \neq cm^{-1}$

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94. In an experiment to determine the surface tension of water by capillary rise, in a capiliary tube of diameter 10^{-3} m water rises to a height of 0.03 m. Calculate the surface tension of water. Given. g = $9.8 ms^{-2}$, density of water = $1000 kgm^{-3}$

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95. A tube of a mencury barometer is 4.5 mm in diameter. What error does surface tension introduce in its reading? Given that angle of contact between mercury and glass is 130° and the surface temion is $540 dy \neq cm^{-1}$ Take density of mercury as $13.6 gcm^{-3}$ and g = $980 cms^{-2}$

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96. A capillary tube of immer diameter 0.5 mm is dipped in a liquid of specific gravity 13.6, surface tension $545dy \neq cm^{-1}$ angle of contact 130°, Find the depression or elevation of liquid in the tube.

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97. Water rises to a height of 10 cm in a capillary tube and mercury falls to a depth of 3.42 cm in the same capillary tube. Compare the surface tensions of water and mercury. Specific gravity of mercury is 13.6. the angle of contact for water is 0° and that for mercury in 135°

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

$7.3 \times 10^{-2} Nm^{-1}$'. $Takethe \angle ofcontact \rightarrow bezero$ and $densityofwater$ –

1.0xx 10^3 kg m^- 3(g = 9.8 m s^-2`) .

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99. Find the difference in levels of mercury in the two limbs of a U-tube, if the diameter of the bore of one limb is 1mm and of the other is 4mm. The surface tension of mercury is $544dy \neq cm^{-1}$, its density is $13.6gcm^{-3}$ and the angle of contact is 130°

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100. Two limbs of a capillary U-tube have the internal diameters of 1mm and 2mm. the tube is held vertically and is partially filled with liquid of surface tension $50dy \neq cm^{-1}$. find the density of liquid if the difference of levels in the two limbs is 1.25 cm. Assume angle of contact to be 0°

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101. A glass capillary tube of internal diameter 0.6 mm is held vertically with the lower end in water and with 80mm of the tube above the surface of water. how much high does the water rise? If the tube is now lowered until 30 mm of its length is above the surface of water what happens? surface tension of water is $72dy \neq cm^{-1}$

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102. If a 5cm long capillary tube with 0.1 mm internal diameter open at both ends is slightly different water having surface tension $75dy \neq cm^{-1}$ what will happen to the water column in the tube.

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103. A vertical capillary tube with inside diameter 0.5 mm is submerged into water, so that the length of its Parth emerging outside the water surface is equal to 25 mm. find the radius of curvature of the meniscus. surface tension of water is $72dy \neq cm^{-1}$

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104. Water rises in a capillary tube to a height 2 cm. in an another capillary tube whose radius is one third of it, how much water will rise? If the first capillary tube is inclined at an angle of 60° with the vertical, then what will be the position of water in the tube.

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105. A tube of conical bore of length 10 cm is just dipped in the water. The diameters of upper and lower are 0.04 cm and 0.06 cm respectively. find the height to which the liquid rises in the tube. given surface tension of water is $70dy \neq cm^{-1}$ and angle of contact is 0°

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106. The lower end of a capillary tube of dimeter 2 mm is dipped 8 cm below the surface of water in a beaker. What is the pressure required in

the tube to blow a hemispherical bubble at its end in water? the surface tension of water is $7.3 \times 10^{-2} Nm^{-1}$ $\rho_w ater = 10^3 kgm^{-3}$ g=$9.8 ms^{-2}$ 1 atmospheric pressure=$1.013 \times 10^5 Nm^{-2}$ Also calculate the pressure inside the bubble.

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107. Calculate the force required to separate two glass plates of area $10^{-2} m^2$ with a film of water 0.05 mm thick between them. surface tension of water is $72 dy \neq cm^{-1}$

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108. Two separate air bubbles (radii 0.002 m and 0.004 m) formed of the same liquid (surface tension `0.70 Nm^-1)~ came together to form a double bubble. Find the radius and sense of curvature of the internal film surface common to both the bubbles.

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109. A small hollow sphere which has a small hole in it is immersed in water to a depth 40 cm before any water penetrates into it. If the surface tension of water is $75dy \neq cm^{-1}$, find the radius of the hole.

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110. What will be the pressure inside a small air bubble of 0.1 mm radius situated just below the free surface of water ? Surface tension is 72 dyne cm^{-1} and atmospheric pressure is 1.013×10^6 dyne cm^{-2}.

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111. Two spherical soap bubbles coalesce. If V is the consequent change in volume of the contained air and S the change in total surface area, show that 3PV+4ST=0, where T is the surface tension of the soap bubble and P is atmospheric pressure.

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112. There is a soap bubble of radius 2.4xx10^(-4)m in air cylinder which is originally at a pressure of 10^(5)(N)/(m^(2)). The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. (the surface tension of the soap film is 0.08Nm^(-1)). The pressure of air in the cylinder is found to be 8.08xx10^(n)(N)/(m^(2)). What is the value of n?

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113. two soap bubbles of radii r1 and r2 coalesce to form a bubble of radius r. If the external pressure is P then the surface tension is T is given by $T = \frac{P\left(r^3 - r_1^3 - r_2^3\right)}{4\left(r_1^2 + r_2^2 - r^2\right)}$

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114. A glass capillary sealed at the upper end is of length 0.11 m and internal diameter 2×10^{-5}m. The tube is immersed vertically into a

liquid of surface tension $5.06 \times 10^{-2} Nm^{-1}$.To what length in cm has the capillary to be immersed so that the liquid levels inside and outside the capillary become the same ? What will happen to the water levels inside the capillary if the seal is now broken?

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Exercise

1. Define surface tension.. Give units and dimensions.

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2. Define surface tension.

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3. How is surface energy related to surface tension of a liquid ?

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4. Explain the difference between surface tension and surface energy.

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5. Define surface tension.. Give units and dimensions.

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6. Define surface energy. Find the relation between surface energy and surface tension.

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7. Define surface energy. Find the relation between surface energy and surface tension.

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8. Explain the difference between surface tension and surface energy.

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9. Explain the difference between surface tension and surface energy.

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10. Define surface tension.

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11. Give molecular theory to explain surface tension.

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12. How one can say that when a large number of drops of a liquid (same size) coalesce to form a big drap, there is always liberation of energy.

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13. Determine excess of pressure in side liquid drop

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14. Determine excess of pressure in side liquid drop

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15. Determine excess of pressure in side air bubble

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16. Determine excess of pressure in side liquid drop

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17. Derive an expression for the rise of liquid in a capillary tube and show that the height of the liquid column supported is inversely proportional to the radius of the tube.

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19. Derive an expression for the rise of liquid in a capillary tube and show that the height of the liquid column supported is inversely proportional to the radius of the tube.

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22. Derive an expression for the rise of liquid in a capillary tube and show that the height of the liquid column supported is inversely proportional to the radius of the tube.

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23. Determine excess of pressure in side air bubble

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24. Determine excess of pressure in side soap solution bubble.

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25. Determine excess of pressure in side air bubble

Watch Video Solution

26. How is surface energy related to surface tension of a liquid ?

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27. Derive an expression for the rise of liquid in a capillary tube and show that the height of the liquid column supported is inversely proportional to the radius of the tube.

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28. Derive the formula $\frac{2T\cos\theta}{r} = h\rho g$ where h the capillary ascent and other symbob have their usual meanings

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29. Derive an expression for the rise of liquid in a capillary tube and show that the height of the liquid column supported is inversely proportional to the radius of the tube.

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