UNIT 1
AN INTRODUCTION TO FLUIDS

1. Anything that flows is a *fluid.*

   Oil is a __________.

2. Gas and water are also fluids.

   Oil, gas, and water can all be made to __________.

3. Solid rock (is/is not) a fluid.

4. Suppose you want to move a piece of solid rock.

   If the rock is not too heavy, you might just __________ it up and carry it.

5. Moving a rock takes *energy.*

   When a person moves a rock, the energy to move the rock is supplied by the __________.

6. When a rock falls from a cliff, then it is gravity that is supplying the __________.

7. Moving *anything* takes energy.

   For a fluid to flow, there (must/need not) be a source of energy.

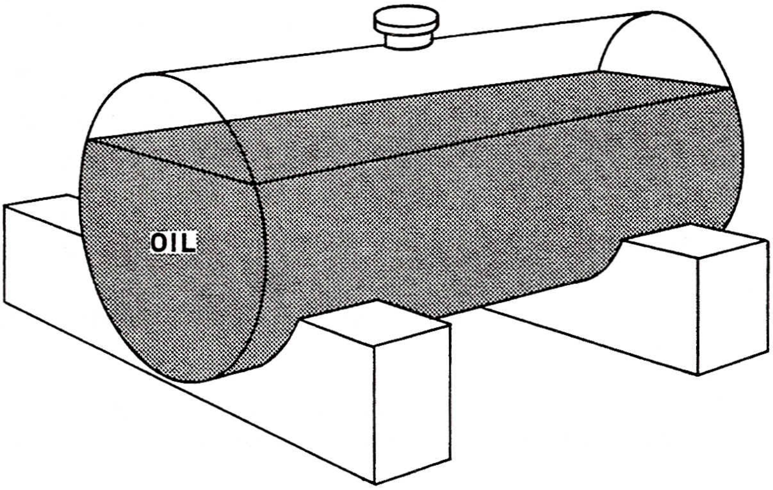
8. When a pump is forcing fluids through a well-bore, the source of energy for flow is the __________.

9. The source of energy for a flowing well is *reservoir pressure.*

   A flowing well produces because of the __________ of the fluids in the reservoir.

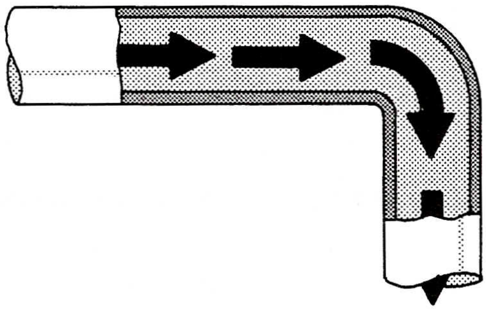
THE NATURE OF FLUIDS

10. Any substance that can flow and that has no definite shape is a *fluid.*



The oil in this tank (has a definite shape/assumes the shape of the tank).

11. This pipeline contains gas.



Gas (flows/does not flow) and has (a definite/an indefinite) shape.

12. Anything that flows and has an indefinite shape is a (liquid/gas/fluid).

13. All liquids and all gases are ____________.

The Three States of Matter

14. Fluids, like all substances, are made up of *atoms.*

    Oil is made up of ____________.

15. The oil and gas found in a reservoir are made up of *hydrogen* atoms and *carbon* atoms.

    Hydrocarbons are substances made up only of atoms of ____________ and atoms of ____________.

16. Oil and petroleum gas are both called ____________.

17. Water is made up of *hydrogen* atoms and *oxygen* atoms (H_2O).

    Water (is/is not) a hydrocarbon.

18. Different oils and petroleum gases are made up of different combinations of hydrogen and carbon atoms.

    A *molecule* is a combination of ____________.

19. Or, H_2O is (an atom/a molecule) of water.

20. CH_4 is (an atom/a molecule) of methane.

21. A substance, water for example, can exist as a gas, a liquid, or a solid.

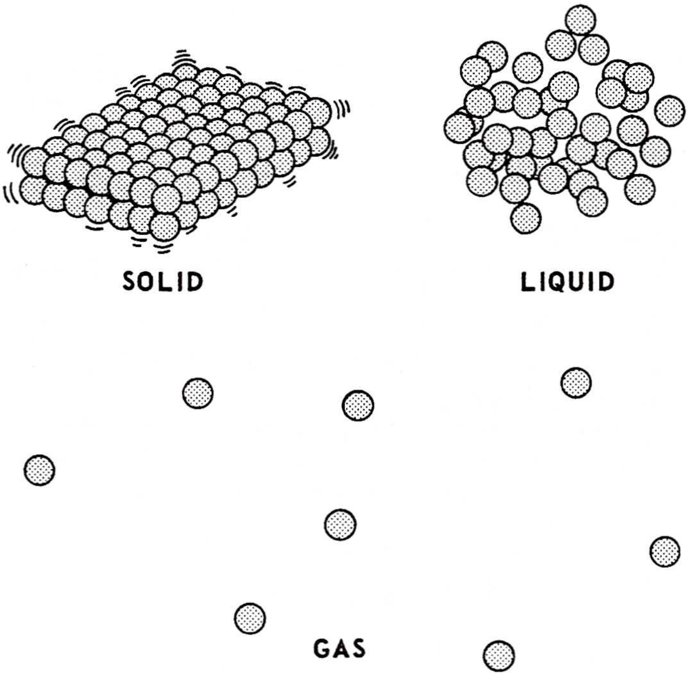
    Ice is a ____________.

    Water is a ____________.

22. We can change solid ice to liquid water by adding ____________.

    We can change the liquid water to a gas by adding even more ____________.

23. Molecules have attractive forces which hold them together.



The attractive forces are strongest between the molecules of a (liquid/solid/gas).

24. The largest spaces are found between the molecules of a ____________.

25. In a solid, the attractive forces are strong enough to hold the ____________ together in a fixed *shape*.

26. So a solid (can/cannot) be made to flow.

27. Compared with the molecules of a gas, liquid molecules are (closer together/farther apart).

28. Molecules are always in motion. *Heat* causes the motion of molecules.

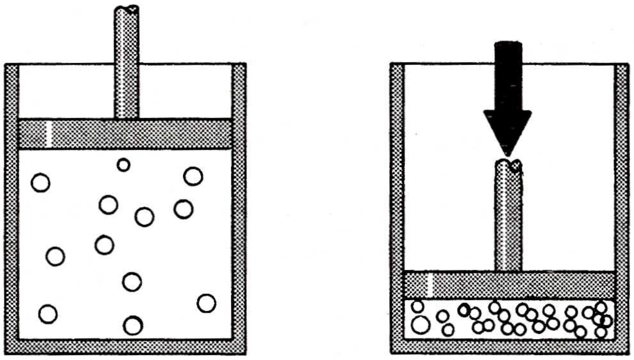
Heating a substance (speeds up/slows down) the movement of its molecules, and causes the molecules to move (closer together/farther apart).

29. Molecules move faster in a (liquid/gas).

30. Molecules are more likely to hit each other and bounce away in another direction in (liquids/gases).

The Compressibility of Gases

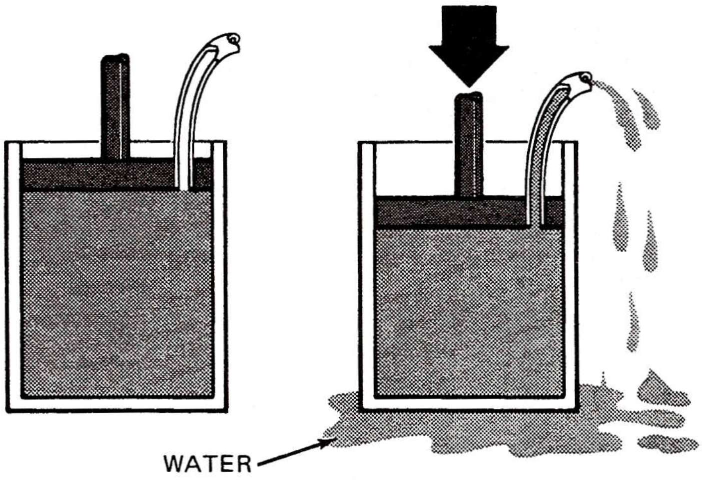
31. Because gas molecules are so far apart, gases are *compressible.*



Gases can be compressed by squeezing the __________ closer together.

32. When a gas is compressed, it occupies (more/less) space.

33. Now the gas in the cylinder is replaced with a liquid.



When the piston is pushed down, the water (is easily compressed/is forced from the container).

34. Because liquid molecules are already close together, a __________ cannot be compressed very much.

35. Liquids are practically incompressible; gases are highly compressible.

Water below its boiling point is (compressible/ practically incompressible).

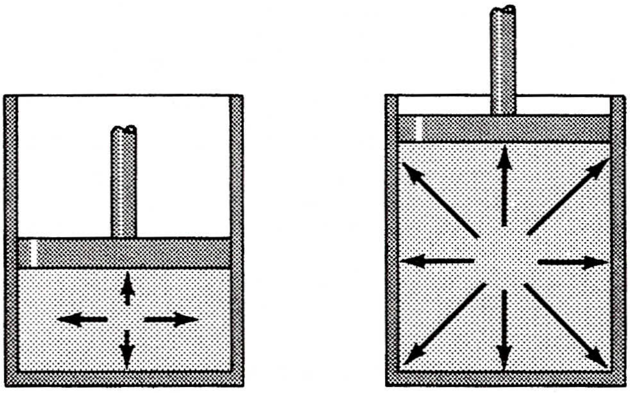
36. At high enough temperatures, the water vaporizes and becomes a gas.

Water vapor, or steam, (is/is not) compressible.

37. Compressibility is a characteristic of gases.

Gases are compressible because of the amount of ____________ between gas molecules.

38. Since gas molecules are so free to move, a small amount of gas can fill even a large container.



The molecules in a small amount of gas move (together/ apart) to fill the larger container.

39. A gas *always* expands to fill a larger space.

And a gas can be ____________ into a smaller space.

40. The space something occupies is its *volume*.

Gases change both their shapes and their ____________ to fit the available space.

41. Because the molecules of a liquid are already close together, liquids change only their (volumes/shapes).

Density

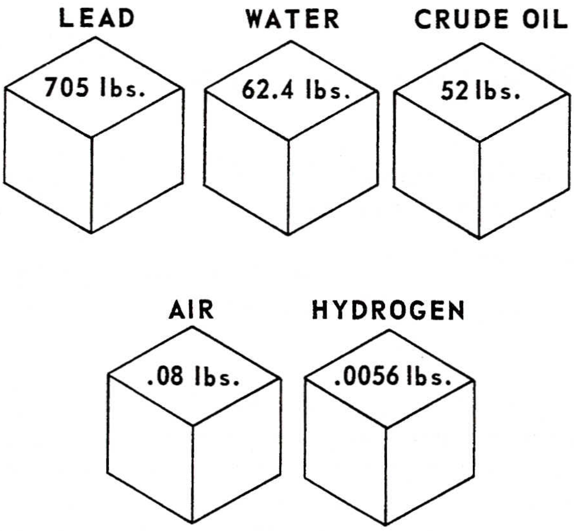
42. Some substances are lighter than others.

    For example, gases are ____________ than liquids.

43. A *dense* forest is one in which the trees are close together.

    In a dense substance, the molecules are (close together/far apart).

44. Molecules have weight; in differing substances, the molecules may be more or less densely packed, and the substances will have different unit weights. **Density** is a term used to express a substance's **weight** per unit volume, for instance, pounds per cubic foot.



A cubic foot of water weighs (more/less) than a cubic foot of oil.

45. (Water/Oil) has the higher density.

46. The density of a substance depends on the weight of the molecules and on the number of molecules in a cubic foot.

    When molecules are packed closer together, the substance has a (higher/lower) density.

47. Water molecules are packed very close together, so water has a (high/low) density.

48. Gases have (high/low) densities.

49. Compressed gas has a (higher/lower) density than noncompressed gas.

50. To compare the densities of different substances, you must weigh them at equal temperatures and pressures.

At different temperatures and pressures, a cubic foot of fluid will contain a different number of molecules, and so the fluid will have a different ____________.

51. *Specific gravity* is another way of indicating the heaviness of a fluid.

The specific gravity of a liquid is its weight compared to the weight of an equal volume of water.

The specific gravity of water is 1; the specific gravity of oil is (more/less) than 1.

52. The specific gravity of a gas is its weight compared to the weight of an equal volume of air.

A gas with a specific gravity of less than 1 is (heavier/lighter) than air.

53. Density and specific gravity are ways of indicating the ____________ of a fluid.

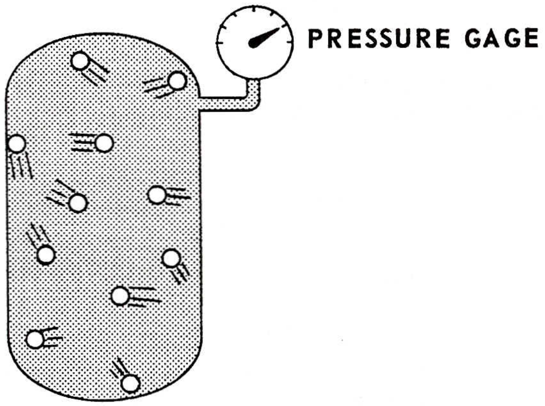
54. Different fluids have (different/the same) densities and specific gravities.

55. Liquids have (higher/lower) densities than gases.

56. Oil has a (higher/lower) density than water.

PRESSURE

57. Fluids exert a *force* on everything they touch.



The gas molecules in this cylinder move rapidly in (one direction/all directions).

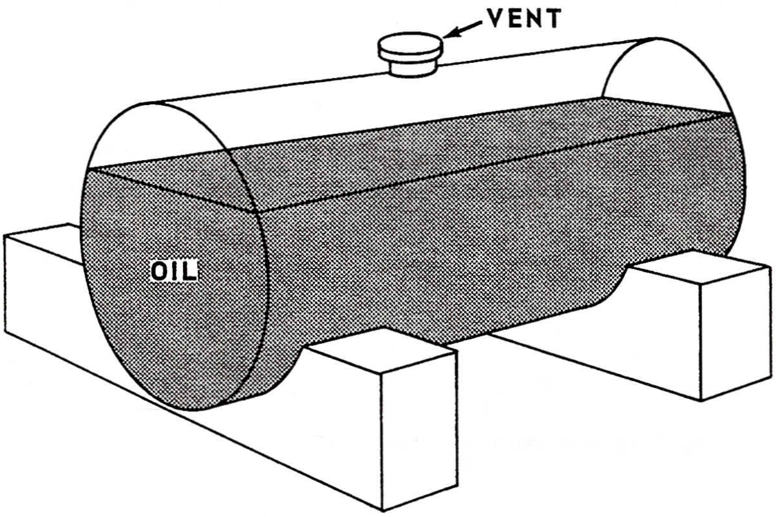
58. As they move, the molecules hit each other and the walls of the ___________.

59. The force of *one* molecule is too slight to be measured, even with the finest instruments.

But the *sum* of all this molecular motion can be measured.

Pressure gages measure (the force of one molecule/the total force of millions of molecules).

60. Like the pressure of a gas, the pressure of a liquid is exerted on everything the liquid touches.



The oil in this vented storage tank exerts ___________ on the tank.

61. The oil also exerts __________ on the air above it.

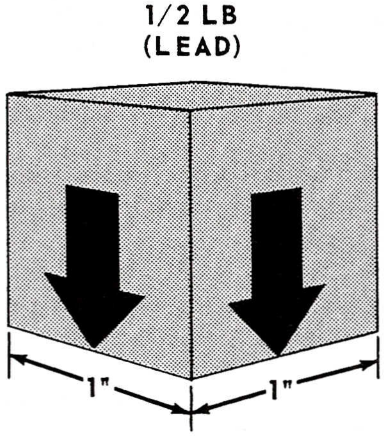
62. And the air exerts __________ on the oil.

63. Pressure is exerted by (liquids only/gases only/all fluids).

And fluids exert pressure on everything they ________.

PSI

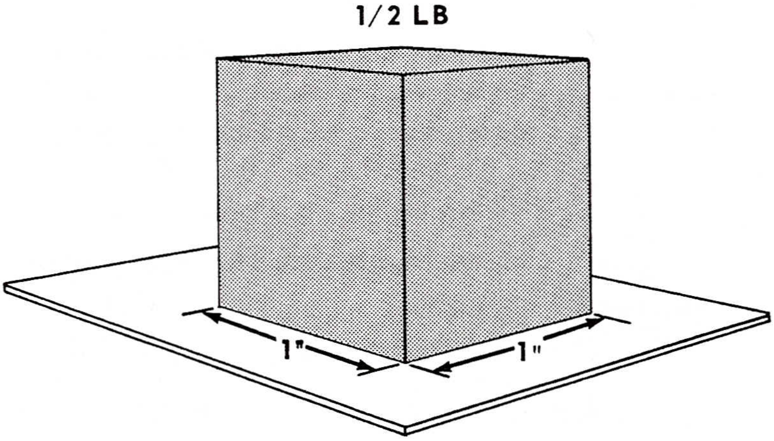
64. Pressure is usually measured in pounds per square inch.



This block of lead weighs about __________ pound.

65. The block exerts a force of __________ pound on the surface underneath it.

66. Area is the length times the width.

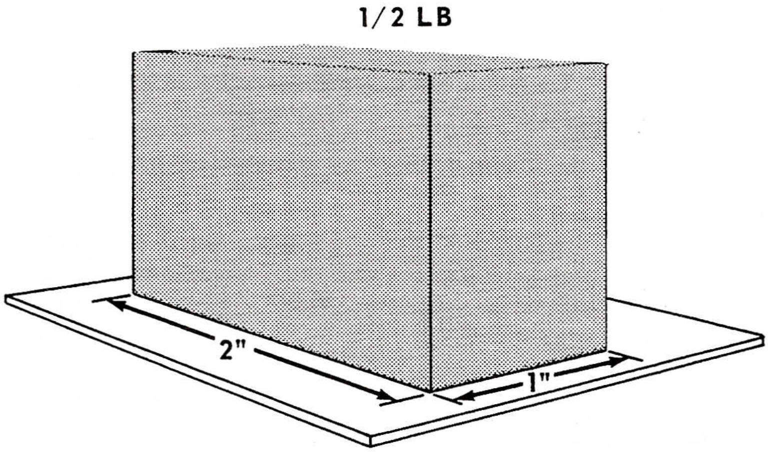


This block rests on an area of __________ square inch.

67. It has a weight of ___________ pound.

68. So the pressure caused by the weight of the block is ___________ pound per square inch.

69. This block weighs ½ pound.



But the area it rests on is ___________ square inches.

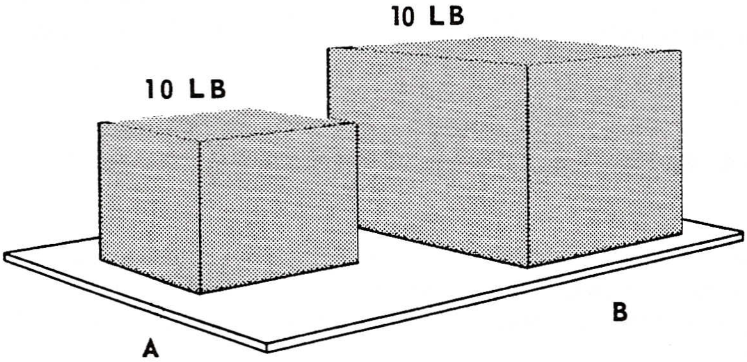
70. *One* square inch under the block has a weight of (1 pound / ¼ pound) resting on it.

71. So this block exerts a pressure of ___________ pound per square inch on the surface below it.

72. Pressure can be defined as force acting on a unit of *area.*

(Pounds/Square inch) is a measure of *area.*

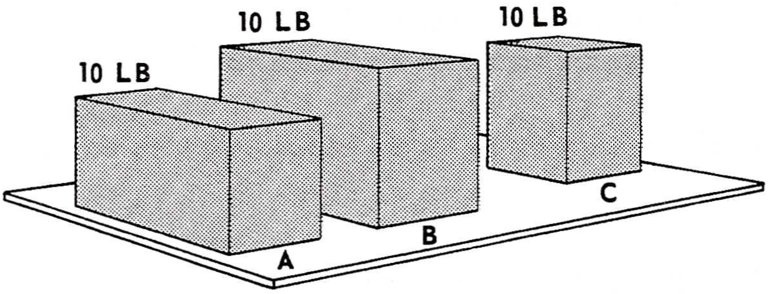
73. Blocks A and B weigh the same amount.



But they exert different pressures because they are acting on areas of ___________ sizes.

74. The force caused by the weight of block B is spread out over a ____________ area.

75. All three of these blocks exert the same *force* on the table below them.



But this force is concentrated in a smaller *area* under block (A/B/C).

76. The pounds per square inch (PSI) is greatest under block (A/B/C).

77. Pressure can be defined as the amount of force exerted on one square inch of area.

Pounds per square inch (abbreviated PSI) is a measure of (force/pressure).

78. Suppose a fluid has a pressure of 20 PSI.

It is exerting a force of ____________ pounds on every ____________ ____________ of area it touches.

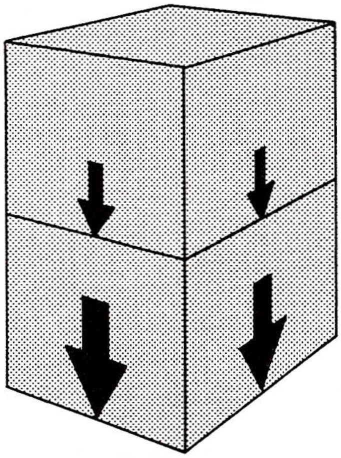
79. An oil reservoir may have a pressure of 2000 PSI to 15,000 PSI.

Thus, reservoir fluid may exert a force of several *tons* on every ____________ ____________ it touches.

80. It is this ____________ which supplies energy in a flowing well.

Hydrostatic Pressure

81. Suppose you stack one block on top of another block.

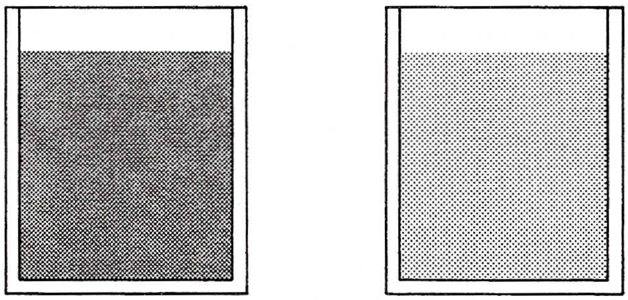


The pressure at the bottom (increases/decreases).

82. The taller the block, the (more/less) force it exerts at the bottom.

83. If a block is made out of lighter material, it exerts ____________ force on one square inch than a heavier block would exert.

84. Water has a higher density than oil.



WATER

A

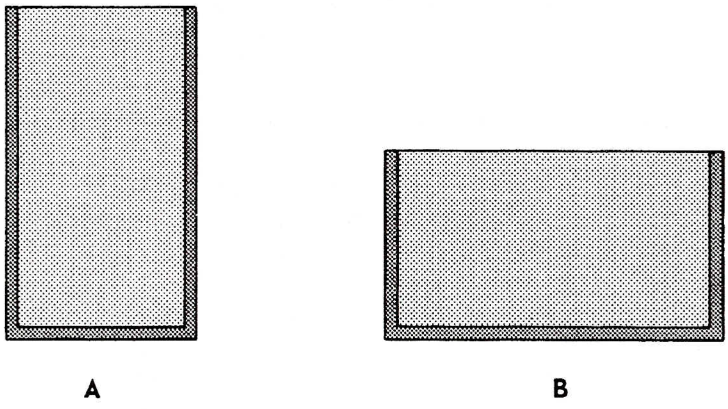
OIL

B

The pounds per square inch is greater at the bottom of tank (A/B).

85. The higher the density of a liquid, the more __________ it exerts on the bottom of its container.

86. Each of these tanks contains the same volume of water.

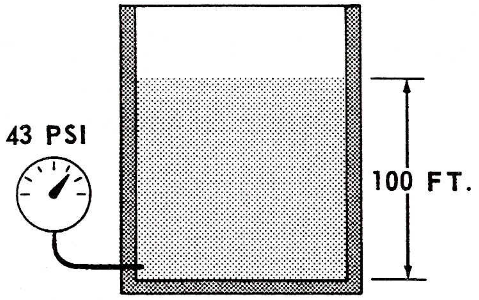


But pressure is greater at the bottom of tank (A/B).

87. The height of a liquid is its *head.*

Liquids with higher heads create (more/less) pressure than liquids with lower heads.

88. The pressure that results from the height and density of a liquid is called *hydrostatic pressure.*



The *head* of this liquid is ____________ feet.

89. The hydrostatic *pressure* of this liquid is ____________ PSI.

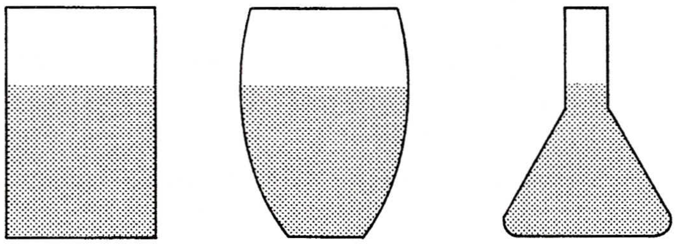
90. As head increases, hydrostatic pressure (increases/ decreases).

91. As density increases, hydrostatic pressure (increases/ decreases).

92. Hydrostatic pressure depends on the ____________ of the liquid and on the ____________ of the liquid.

93. Hydrostatic pressure does not depend on the *shape* of the liquid's container.

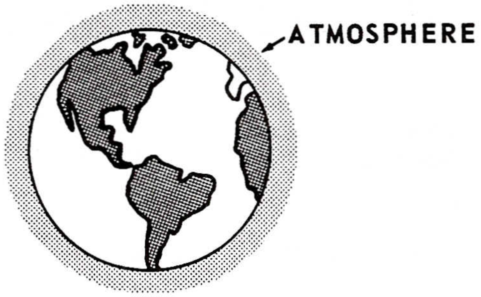
Each of these open tanks contains a 10-foot head of water.



The pounds per square inch at the bottom of each is (the same/different).

Atmospheric Pressure

94. The atmosphere is a "blanket" of gases about 7 miles high which surrounds the earth. This atmosphere exerts 14.7 pounds of (absolute) pressure on each square inch of earth.



Or, like the hydrostatic pressure of a liquid, atmospheric pressure is caused by the __________ and __________ of the gases above the earth.

95. Although atmospheric pressure is a form of static pressure, we generally do not think of gases as exerting *hydrostatic* pressure.

Hydrostatic pressure is ordinarily used to mean only the pressure exerted by the height and density of a __________.

96. Pressure gages do not show atmospheric pressure.

At atmospheric pressures, an oil-field pressure gage reads (14.7 / 0) PSI.

97. Since barometers and some other instruments do show atmospheric pressure, the pressure shown on a *gage* is specified by the letters PSIG.

PSIG stands for ____________ per square inch ____________.

98. A fluid with the pressure 20 PSIG exerts a force of 20 pounds (more/less) than atmospheric pressure on every ____________ ____________ it touches.

Pressure, Temperature, and Volume

99. Heat is a form of energy.

When you heat a fluid, you are (increasing/decreasing) its energy.

100. When a fluid is heated, its molecules move (faster/slower).

101. As liquid molecules are heated, the spaces between them get larger.

If enough heat is added, the liquid turns to a ____________.

102. If the gas is cooled enough, it turns back to a ____________ again.

103. Cooling a fluid is (adding/removing) energy.

104. Removing heat from a fluid (increases/decreases) the motion of its molecules.

105. Temperature is one way of measuring heat.

70°F is a measure of ____________.

106. *Volume* is the amount of space something occupies.

Barrels is a measure of ____________.

107. A barrel of oil is 42 gallons.

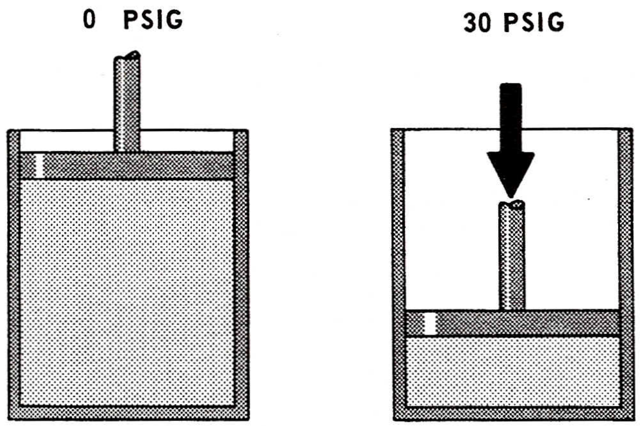
When large volumes are being handled, oil is measured in (gallons/barrels).

108. Cubic feet, gallons, and barrels are all measures of ____________.

109. Gallons and barrels are (gas/liquid) volume measures.

110. Gas volume is usually measured in ____________ ____________.

111. When a gas is compressed, it occupies less space.



Compressing a gas *decreases* its ____________.

112. As the gas molecules are squeezed into a smaller space, they exert more force on every square inch they touch.

Compressing a gas increases its ____________.

113. As the gas molecules are squeezed together, they also move faster and the gas gets hotter.

Gas compressors usually must be cooled to remove some of the ____________ caused by compression.

114. Since liquids are practically incompressible, liquids are usually considered to have fixed volumes.

But at very high pressures, liquids can be ____________ somewhat.

115. Under most conditions, when fluid pressure increases, its temperature also ____________.

116. Compressing a fluid:

(increases/decreases) its volume;

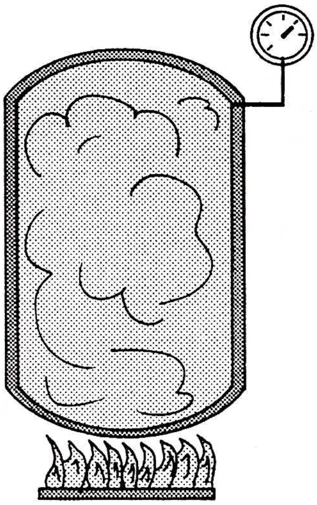
(increases/decreases) its temperature.

117. In hot weather, the level of oil rises in an open container or vented storage tank.

Heat causes fluids to (expand/contract).

118. As temperatures increase, fluid volume (increases/decreases), if the fluid is free to expand.

119. The gas in this cylinder is trapped and cannot expand.



HEAT

Heating the gas increases its (volume/pressure).

120. In an open container, increasing the temperature of a fluid increases its volume.

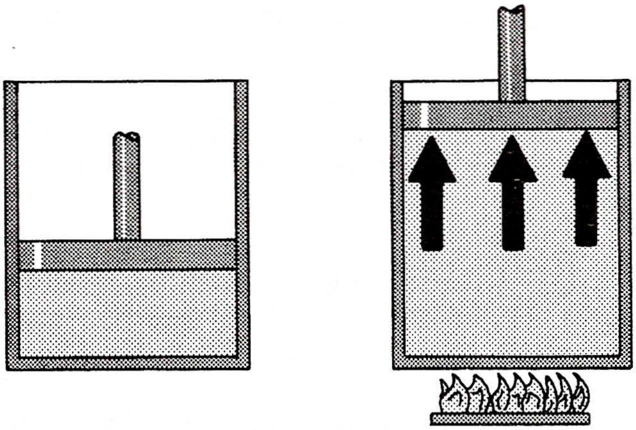
In a closed container, increasing the temperature of a fluid increases its ____________.

121. The pressure of a fluid in a closed container can be increased by:

(increasing/decreasing) its volume; or by

(increasing/decreasing) its temperature.

122. Suppose this pressurized gas is supporting a movable piston.



When the gas is heated, it (expands/contracts), and the same amount of pressure will raise the piston (higher/lower).

123. Or, as temperature increases, volume (increases/decreases), while pressure remains the same.

124. If the heated gas is trapped and cannot expand, (pressure/volume) will increase, while (pressure/volume) remains the same.

125. Heat and pressure are both forms of energy.

The energy of a fluid can be increased by heating the fluid, or by applying ___________ to the fluid.

126. Both heat and compression increase the ___________ of a fluid.

127. Both cooling a fluid and reducing the pressure *on* a fluid (increase/decrease) its energy.

128. At the very high pressures in oil reservoirs, gas can be compressed into a liquid state.

Gas that is compressed into a liquid state has (more/less) energy than gas that is turned into a liquid by cooling it.

REVIEW AND SUMMARY

129. Liquids and gases are called ____________ because all liquids and gases can be made to ____________.

130. Gases are compressible fluids; liquids are practically ____________ fluids.

131. Density is a measure of the ____________ of a fluid.

132. PSIG is an abbreviation for __________ per __________ __________ gage.

133. PSIG is a measure of fluid ____________.

134. Hydrostatic pressure is caused by the ____________ and ____________ of a liquid.

135. When a fluid is heated, its pressure ____________, if volume remains the same.

136. Compressing a gas (increases/decreases) its pressure and (increases/decreases) its volume.

137. When pressure is applied to a fluid, temperature (increases/decreases).