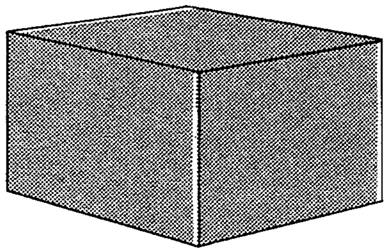
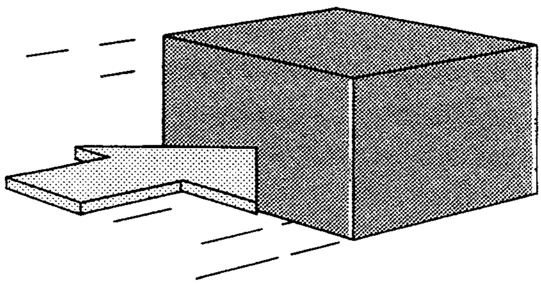
UNIT 2

THE MECHANICS OF FLOW

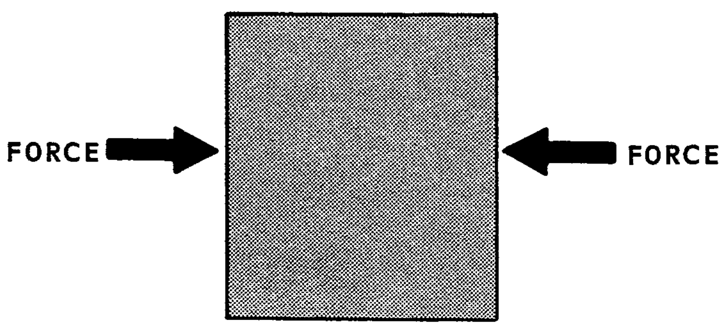
1. Energy is needed to make things move. Force is energy applied in a direction.





Applying force to this block of wood makes it ______________.

2. This block is being pushed from both ends.



If both forces are the same, the block (moves/does not move).

3. If one force is greater than the other, the block will move toward the (larger/smaller) force.

4. Force *applied to a fluid* is transmitted equally throughout the fluid.

   Force *stored* in a fluid is measured as (force/pressure).

5. Pressure is defined as (force/force per unit of area).

6. Pressure is also defined as *stored,* or *potential,* energy.

   Fluids store force in the form of pressure.

   This pressure, or stored energy, can then be used to make the fluid ____________.

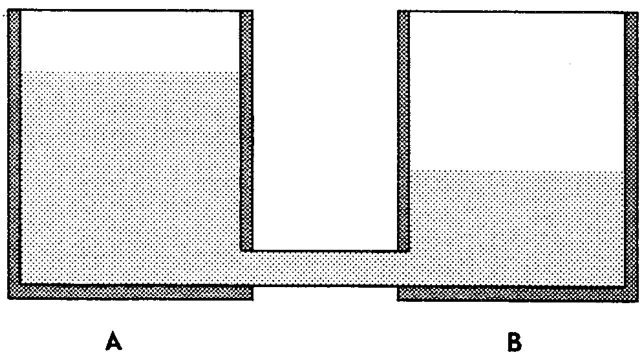
PRESSURE AND FLOW

7. The force of gravity acting on a liquid makes it flow (uphill/downhill).

8. Even though the liquid is not moving, gravity exerts a force on its molecules.

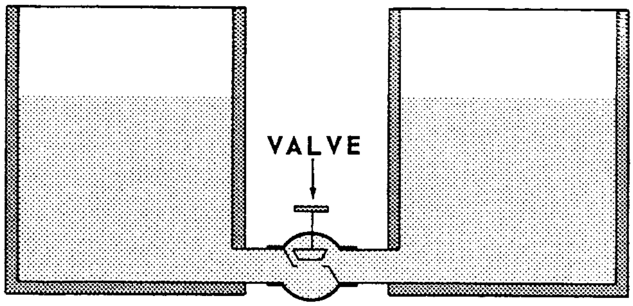
   Hydrostatic pressure is the pressure caused by the force of ____________ acting on the molecules of a liquid.

9. Hydrostatic pressure can be used to move liquids in surface vessels.



   Because there is a higher hydrostatic pressure at the bottom of tank A, oil will flow from (A to B / B to A).

10. These two tanks contain oil of the same density.



The pressure at the bottom of tank B is (less than/the same as/greater than) the pressure at the bottom of tank A.

11. This is because the __________ and density of the oil is the same in each tank.

12. We know that energy is needed to make things move.

When the pressures are the same, the amount of energy in the two tanks is (the same/different).

13. When the pressures are the same, the oil does not __________.

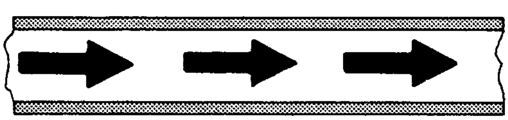
Pressure Drop

14. Fluids flow *into* areas of lower pressure.

For flow to occur, pressures across the fluid must be (the same/different).

15. Flow is caused by (high pressures/pressure differences).

16. Fluid is flowing from A to B.



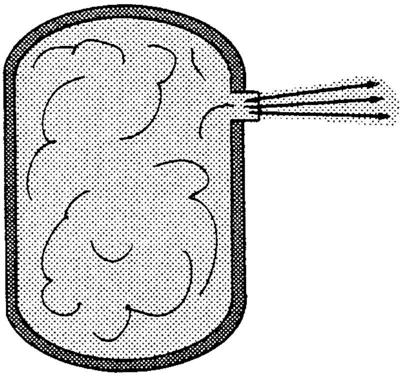
Pressure must be greater at (A/B).

Now turn the page, turn the book over, and go on.

17. Suppose we increase the pressure at A.

Flow will be (faster/slower). fas

18. This high-pressure gas is being vented to the atmosphere.

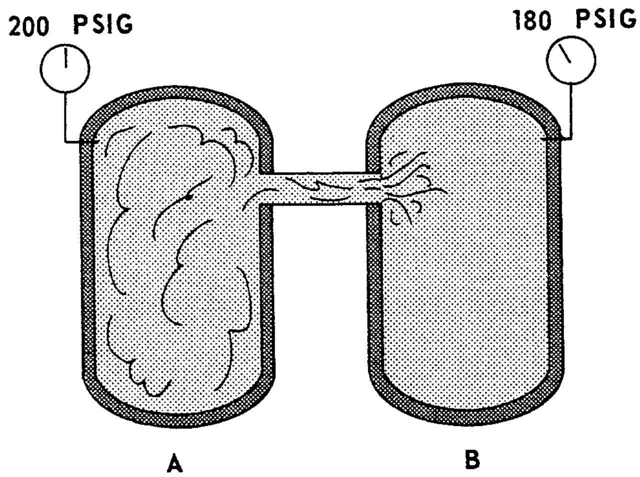


The flow of gas from the cylinder is very (fast/slow). fas

19. The flow is fast because atmospheric pressure is low, compared with the pressure of the gas in the cylinder.

The atmosphere offers a (high/low) *resistance* to flow from the cylinder. lo

20. Now the gas is being transferred to another high-pressure gas cylinder.



Pressure in cylinder B is (above/below) atmospheric pressure. ab

21. The *resistance* of the gas in cylinder B is (more/less) than the resistance of the atmosphere. m

22. Flow would be *slower:*

_____ from cylinder A to cylinder B. — fror
_____ from cylinder A to the atmosphere. — cyli

23. When there is more resistance at the outlet, flow is (faster/slower). — slov

24. In a flowing fluid, the difference between the inlet pressure and the outlet pressure is called the *pressure drop*.

When pressure at the outlet is higher, the pressure drop is (larger/smaller). — sma

25. When pressure at the outlet is lower, the pressure drop is (larger/smaller). — larg

26. The *rate* of flow depends on the pressure drop.

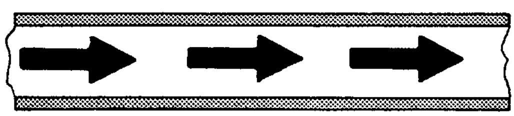
A larger pressure drop causes a (higher/lower) rate of flow. — higl

Flow Rate

27. The *rate* of flow is the volume of fluid moved in a given length of time.

A well that flows at 200 barrels per day has a (higher/lower) flow rate than a well that produces 100 barrels per day. — higl

28. Liquid is flowing through this pipe.



To find the rate of flow, you need to know the __________ of liquid that flows in a given length of time. — volu

29. The longer it takes for a certain volume of fluid to flow, the (higher/lower) the flow rate. lo

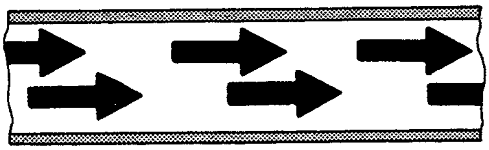
30. The faster a certain volume of fluid flows, the ____________ the flow rate. hi

31. Flow rate is increased by:

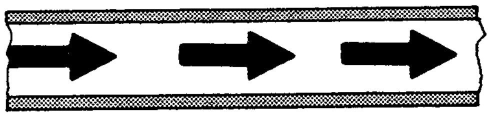
(increasing/decreasing) the volume of fluid flowing; or by in

(increasing/decreasing) the time it takes to flow. de

32. Liquid is moving through these two pipe sections at the same speed.



A



B

Since pipe A has a larger diameter, it carries __________ liquid in the same length of time. m

33. The flow rate is higher in pipe (A/B). A

34. (Barrels/Barrels per day) is a measure of flow rate. B

35. Flow rate may also be measured as the number of cubic feet of gas passing through a meter in an hour.

Cubic feet refers to (time/volume). v

36. If 1000 cubic feet of gas moves through a gas meter in a day, the flow rate is ____________ cubic feet/day.

37. 1000 cubic feet is also written *1 MCF*.

M is an abbreviation for (one/thousand).

38. 1 MCF of gas flowing through a line in one day is a (higher/lower) flow rate than 1 MCF flowing in two days.

39. In an oil field, the flow rates of gas and oil are measured separately.

MCF/day is a measure of the flow rate of ____________.

40. Bbl./day is a measure of the flow rate of ____________.

41. Comparing the volume of gas produced with the volume of oil produced gives the *Gas-Oil Ratio* (GOR) of a well.

With a GOR of 2000 CF/bbl., a well is producing 2000 cubic feet of ____________ with every barrel of ____________.

42. CF/bbl. is a measure of (flow rate/GOR).

43. If the flow rate of gas increases and the flow rate of oil remains the same, the GOR (increases/decreases/remains the same).

44. If the flow rate of oil increases and the gas flow rate remains the same, the GOR (increases/decreases/remains the same).

45. If the flow rates of both the gas and oil increase in the same *proportion* or *ratio*, the GOR ____________ ____________ ____________.

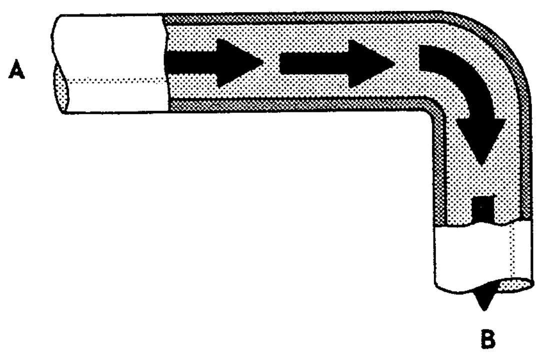
46. Or, flow rate tells how ____________ fluid is being produced in a given length of ____________.

47. The GOR tells the number of cubic feet of ____________ ga
produced with every ____________ of oil. ba

48. The GOR is calculated by comparing flow rates.

To calculate the GOR, the volumes of gas and oil that are compared are the volumes produced in (the same/ a different) period of time. the

49. For any fluid, the *rate* of flow depends on the pressure drop.



Flow in this line can be increased by increasing the pressure at (A/B) or by decreasing the pressure at (A/B).

A
B

50. Increasing the pressure at A (increases/decreases) the pressure drop. in

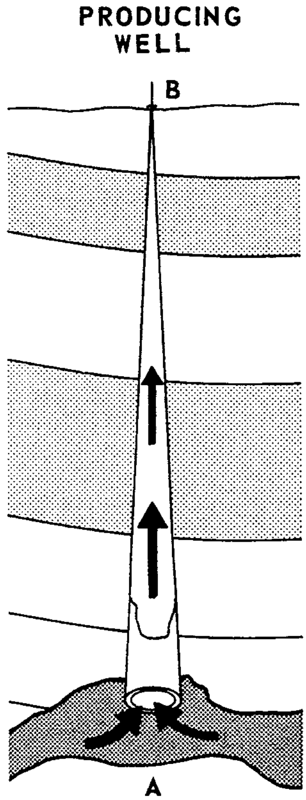
51. But increasing the pressure at B *decreases* the pressure drop in this line.

Smaller pressure drops cause (higher/lower) flow rates. lo

52. To increase the flow rate, (increase/decrease) the pressure drop. in

53. To decrease the flow rate, (increase/decrease) the pressure drop. de

54. The flow rate through this well-bore will decrease if the pressure at A decreases.



Or, the rate can be reduced from the surface by (increasing/decreasing) the pressure at B. ir

55. Increasing the pressure at *A* (increases/decreases) the pressure drop through the well-bore. ii

56. Increasing the pressure at *B* (increases/decreases) the pressure drop through the well-bore. d

57. Suppose a fluid flowing through a surface line at a rate of 10 bbl./day needs a pressure drop of 20 PSIG to flow from point A to point B.

If the pressure at A is 100 PSIG and the pressure at B is 80 PSIG, the fluid (will/will not) flow from A to B. w

58. If the pressure at A is 200 PSIG and the pressure at B is 80 PSIG, the fluid will flow:

____ faster than 10 bbl./day fa
____ at the rate of 10 bbl./day
____ slower than 10 bbl./day.

59. In order to flow at a rate of 15 bbl./day, the fluid will need a ____________ pressure drop than 20 PSIG from gr
point A to point B.

Velocity

60. *Velocity* is the speed of flow.

The faster a fluid flows, the (higher/lower) its velocity. h

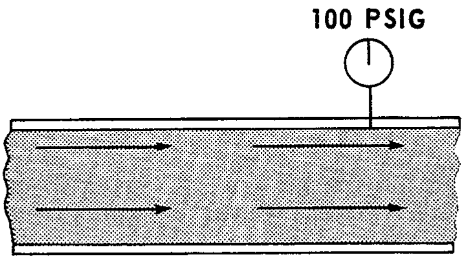
61. Pressure is potential energy, or stored energy.

Velocity is (stored/moving) energy. m

62. When a liquid or gas is flowing, its pressure is being converted to velocity.

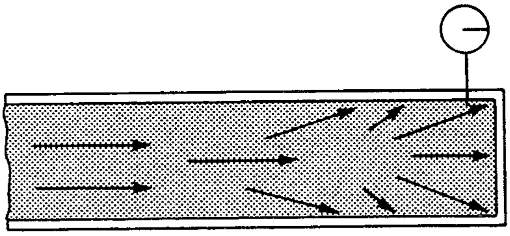
Potential energy is being changed to ____________ m
energy.

63. During flow, energy is being exerted in a forward direction.



Because it is flowing, the fluid exerts (more/less) l
pressure on the pipe around it.

64. Suppose flow is suddenly blocked.



The pressure on the pipe (increases/decreases).

65. A fluid that is not flowing has a higher *pressure* than the same fluid has during flow.

As pressure is converted to velocity, the pressure of the fluid (increases/decreases).

66. Converting pressure to velocity does not change the *energy* of the fluid.

But when a fluid is not moving, its energy is stored energy, or (pressure/velocity).

67. When a fluid is flowing, some of its energy is moving energy, or ____________.

68. Increasing the velocity of flow (increases/decreases) the pressure of the fluid.

69. And *decreasing* the velocity of flow increases the ____________ of the fluid.

70. Anything that reduces the velocity of a flowing liquid or gas (increases/decreases) the pressure of the fluid at that point.

71. Increasing the velocity of flow decreases the ____________ of the fluid in the line.

72. To review:

When velocity increases, pressure ____________.

When velocity decreases, pressure ____________.

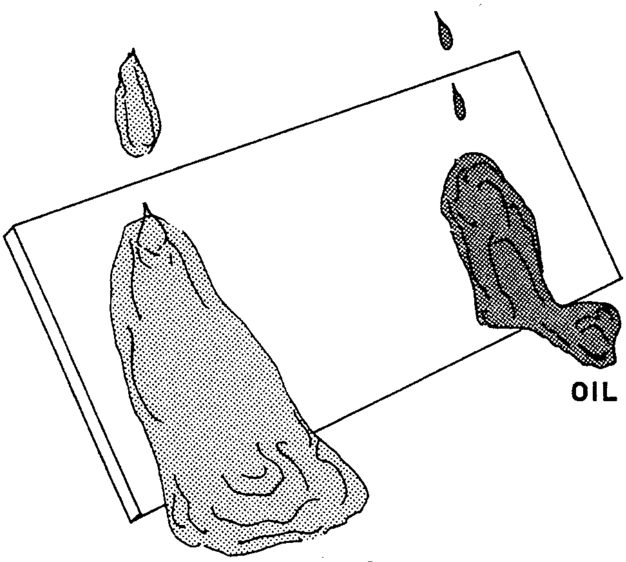
Friction

73. *Friction* is a resisting force to flow.

Part of the pressure stored in the fluid is used in overcoming the __________ in the line.

fr

74. Some liquids resist flow more than others.



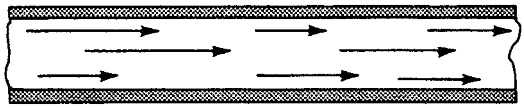
Most oils are more viscous (thick) than water and resist flow (more/less) than water.

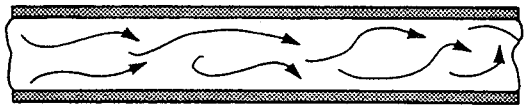
75. Because oil is thicker, it is (harder/easier) to move than water.

76. The same pressure drop will cause a faster flow rate for (oil/water).

77. At the same velocities, there is more friction when (water/oil) is flowing.

78. There is also more friction at high *velocities.*





At higher velocities, flow is (laminar/turbulent). tu

79. In turbulent flow, the fluid is in friction with itself as well as with the pipe.

Fluid-to-fluid friction is greater in (laminar/turbulent) flow. tu

80. Friction between the fluid and the pipe is sometimes called drag.

At the same velocities, there is more drag when (oil/ water) is flowing. oi

81. As velocity increases, drag (increases/decreases). in

82. To review:

As a fluid flows, its pressure (increases/decreases). d

Increasing the velocity of flow decreases the __________ of the fluid. p

Increasing the velocity of flow also increases the amount of ____________ in the line. fr