# PRESSURE

## Pressure

1. Pressure is defined as which of the following?
   - A Force per unit of depth
   - B Area per unit of force
   - C Force per unit of area
   - D Mass per unit of volume

2. The pressure exerted by a fluid on a container surface is caused by which of the following?
   - A The weight of the fluid above the container surface
   - B The collisions between the fluid particles and the container surface
   - C The atmospheric pressure above the fluid
   - D None of the above

3. Which of the following is the SI unit of pressure (or its equivalent)? (Select all that apply)
   - A $N/m^2$
   - B atm
   - C $kg/m^3$
   - D Pa

4. Which of the following are valid units of pressure? (Select all that apply)
   - A bar
   - B psi
   - C inHg
   - D atm

5. A cylinder is partially filled with water and a piston is placed on the surface of the water as shown in Figure 1. The piston is then pushed down with a force of magnitude $F$ which exerts a pressure of $P$ on the water. If the radius of the piston is $r$, what is the magnitude of $F$ in terms of the other variables?

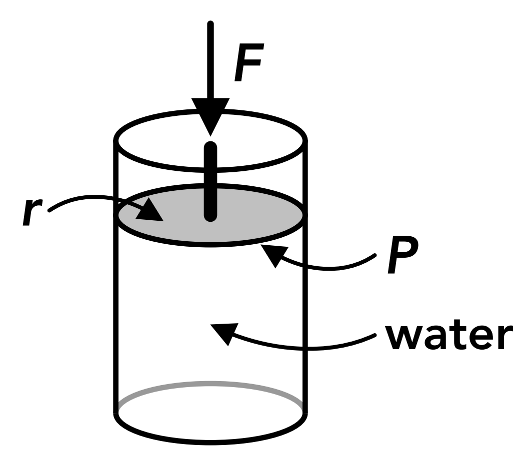

Figure 1

   - A $\frac{P}{\pi r^2}$
   - B $2\pi r P$
   - C $\frac{\pi r^2}{P}$
   - D $\pi r^2 P$

6. The pressure at the bottom of a tank of water is $P$ which exerts a force of magnitude $F$ on the bottom surface of the tank as shown in Figure 2. What is the pressure $P$ in terms of the variables shown?

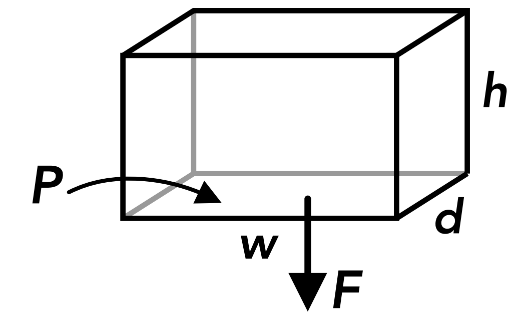

Figure 2

A $\frac{F}{wd}$

B $wdhF$

C $\frac{wd}{F}$

D $\frac{F}{wdh}$

7. A person fills their car's tires with air until they are at a pressure of 34 psi. What is the tire pressure in units of Pa?

8. A meteorologist uses a mercury barometer to measure the true atmospheric pressure on a rainy day. The barometer reads 29.4 inHg. What is the true atmospheric pressure in units of atm?

9. When an airplane is at an altitude of 30,000 feet the outside atmospheric pressure is 30,398 Pa. What percent of the normal atmospheric pressure at sea level (1 atm) is the pressure at 30,000 feet?

10. The tube shown in Figure 3 has a radius of 4 cm and is filled with mercury. If the mercury exerts a force of 13 N on the bottom surface of the tube, what is the pressure at the bottom of the tube?

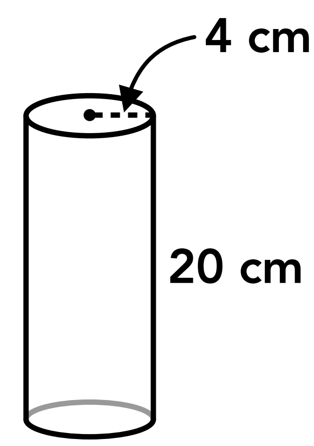

Figure 3

11. The container shown in Figure 4 is partially filled with oil and then a square piston with a side length of 25 cm is placed on the surface of the oil. A force is applied to the piston which exerts a pressure of 160 Pa on the oil. What is the force applied to the piston?

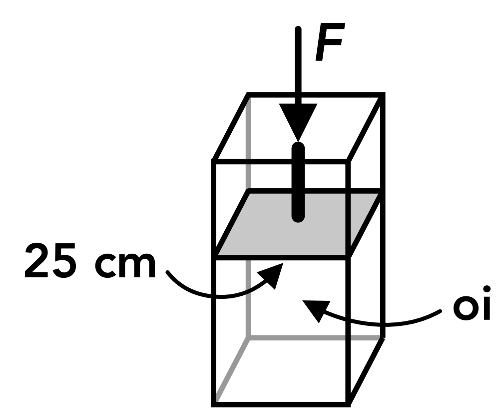

Figure 4

## Absolute Pressure and Gauge Pressure

12. Which of the following describes an absolute vacuum? (Select all that apply)
    - A. A pressure that is less than atmospheric pressure
    - B. The pressure in a container with zero fluid particles inside of it
    - C. A pressure that is equal to atmospheric pressure
    - D. A pressure at a point that is lower than pressure surrounding that point

13. Which of the following is the average atmospheric pressure at sea level on earth? (Select all that apply)
    - A. 100,000 Pa
    - B. 1 Pa
    - C. 1 atm
    - D. 101,325 Pa

14. Absolute pressure is measured relative to which of the following?
    - A. Gauge pressure
    - B. Atmospheric pressure (or another reference pressure)
    - C. Zero absolute pressure (an absolute vacuum)
    - D. Zero gauge pressure

15. Gauge pressure is measured relative to which of the following?
    - A. Atmospheric pressure (or another reference pressure)
    - B. Zero absolute pressure (an absolute vacuum)
    - C. Absolute pressure
    - D. None of the above

16. True or false: An absolute pressure can have a negative value.

17. True or false: A gauge pressure can have a negative value.

18. A beaker of water is open to the atmosphere as shown in Figure 5. What is the absolute pressure of the water at the top surface?
    - A. 0 atm
    - B. Between 0 atm and 1 atm
    - C. 1 atm
    - D. Greater than 1 atm

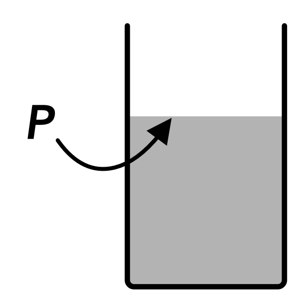


Figure 5

19. A beaker of water is open to the atmosphere as shown in Figure 5. What is the gauge pressure of the water at the top surface?
    - A. 0 atm
    - B. Between 0 atm and 1 atm
    - C. 1 atm
    - D. Greater than 1 atm

20. The gauge pressure at a depth of 2 m in a pool of water is 19,600 Pa. What is the absolute pressure at the point?

21. The absolute pressure of the air in a tire is 30 psi. What is the gauge pressure in the tire in units of Pa?

22. The atmospheric pressure at an altitude of 30,000 feet is 0.3 atm. If the gauge pressure inside the cabin of an airplane at that altitude is 48,000 Pa, what is the absolute pressure inside the airplane in units of Pa?

23. The absolute pressure of the air inside of the International Space Station (ISS) is 100 kPa. If we assume that outer space at the altitude of the ISS is a perfect vacuum, what is the gauge pressure in the ISS in units of atm?

## Pressure and Fluid Depth

24. How is the pressure in a static fluid related to the depth below the fluid surface?
    - A Pressure increases with depth
    - B Pressure does not change with depth
    - C Pressure decreases with depth
    - D Any of the above may be true

25. Pressure increases with depth for which of the following?
    - A Liquids
    - B Gasses
    - C Liquids and gasses
    - D None of the above

26. The absolute pressure at a point below the surface of a fluid depends on which of the following? (Select all that apply)
    - A The density of the fluid
    - B The depth of the point below the fluid surface
    - C The atmospheric pressure above the fluid surface
    - D The gravitational acceleration

27. Which of the following is the gauge pressure $P$ at the point in the liquid shown in Figure 6 if the density of the liquid is $\rho$?
    - A $P_{atm}$
    - B $\rho g h - P_{atm}$
    - C $\rho g h + P_{atm}$
    - D $\rho g h$

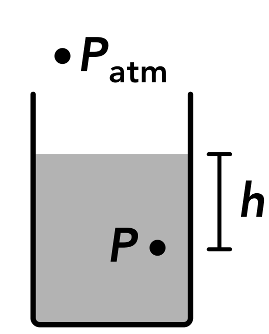

Figure 6

28. The U-tube shown in Figure 7 contains only water and is open at both ends. The two points shown are at the same height. If the gauge pressure of $P_1$ is 0.03 atm, the gauge pressure of $P_2$ is

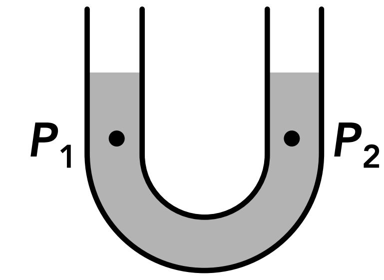


Figure 7

- A less than 0.03 atm
- B 0.03 atm
- C greater than 0.03 atm
- D cannot be determined

29. A container of liquid is shown in Figure 8. The absolute pressure of $P_1$ is 111,000 Pa. And the density of the liquid is $\rho$. Which of the following represents the absolute pressure of $P_2$?

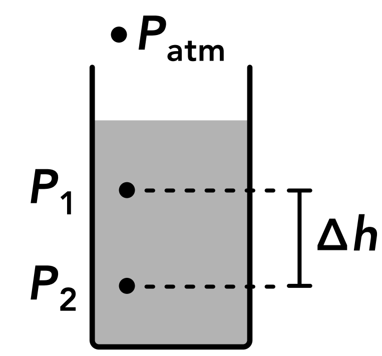


Figure 8

- A $\rho g \Delta h$
- B 111,000 Pa
- C 111,000 Pa + $\rho g \Delta h$
- D $\rho g \Delta h + P_{atm}$

30. A balloon is filled with air and then connected to one side of a U-tube as shown in Figure 9. The tube contains water and the other end of the tube is open. The two points shown are at the same height. What is the relationship between the the absolute pressures at the two points?

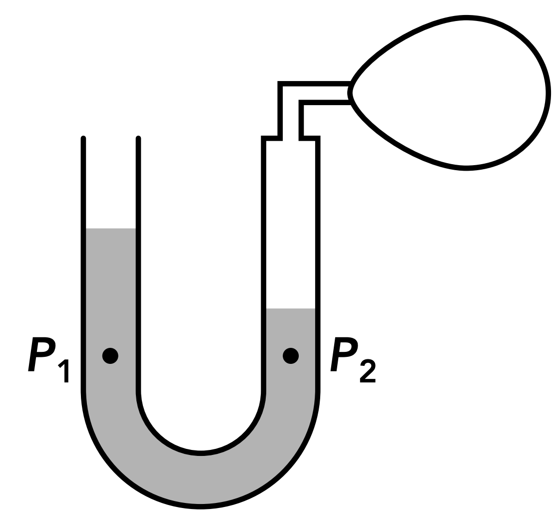


Figure 9

- A $P_1 = P_2$
- B $P_1 > P_2$
- C $P_1 < P_2$
- D Cannot be determined

31. The container shown in Figure 10 is mostly filled with liquid. Points A and B are at the same height, and points C and D are at the same height. What is the relationship between the gauge pressures at each point?

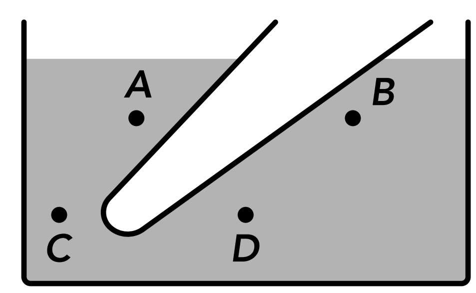


Figure 10

- A $(P_B = P_D) < (P_A = P_C)$
- B $P_B < P_A < P_D < P_C$
- C $P_A = P_B = P_C = P_D$
- D $(P_A = P_B) < (P_C = P_D)$

32. A person holds one end of a hose out of a window and the other end is closed off and is resting on the ground. The person fills the hose to the top with water. What is the absolute pressure in the hose at a point 3 m below the top of the hose?

33. A scuba diver is swimming in the ocean at a depth of 40 m. What is the gauge pressure of the water at that depth in units of atm? Use 1,030 kg/m³ for the density of ocean water.

34. A hiker opens a bottle of hot coffee that they brought to the top of a mountain. The atmospheric pressure at that altitude is 72% of the atmospheric pressure at sea level. What is the absolute pressure of $P$ as shown in Figure 11? Assume coffee has a density of 1,006 kg/m³.

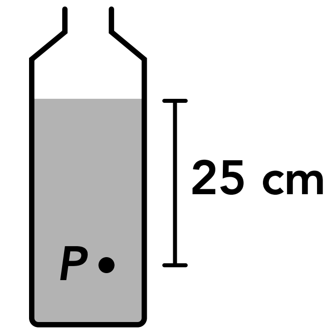

Figure 11

35. A water tower is shown in Figure 12. The top of the tower is open to the atmosphere and the bottom is connected to a pipe that runs below the ground and up to the bottom of a nearby house where the pipe is then closed off with a valve. What is the gauge pressure $P$ in the pipe as it enters the house at ground level?

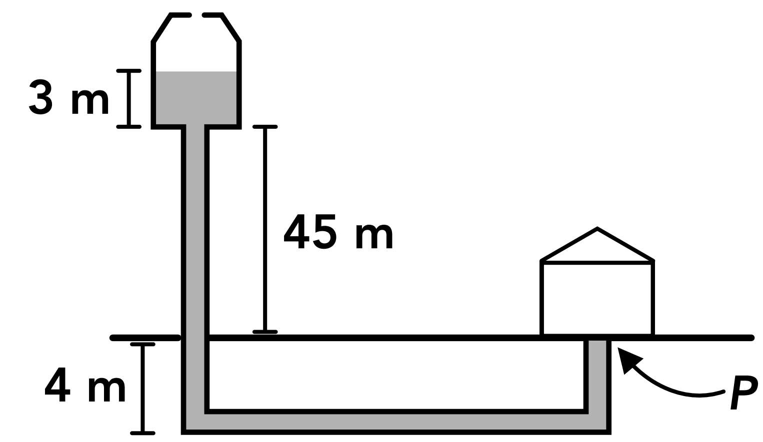

Figure 12

36. A balloon is filled with air and then connected to one side of a U-tube as shown in Figure 11. The tube contains water and the other end of the tube is open. The absolute pressure of the air in the balloon $P_B$ is 103,400 Pa. What is the difference in height $\Delta h$ between the top surface of the water on the left and right sides of the tube?

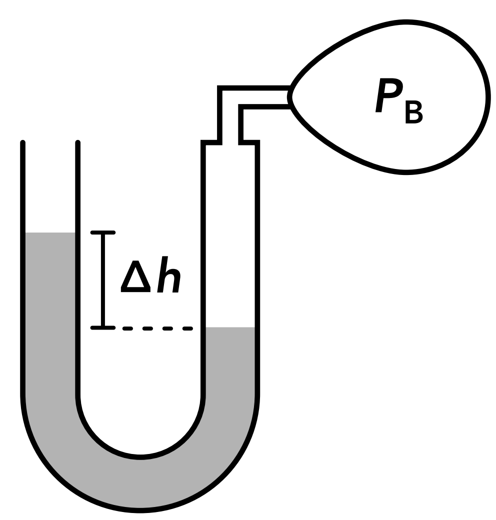

Figure 13

37. A mercury barometer is shown in Figure 12. The large diameter section at the bottom is open to the atmosphere and the space above the mercury in the smaller vertical tube can be considered an absolute vacuum. What is the true atmospheric pressure that is being measured by this barometer? Use 13,600 kg/m³ for the density of the mercury.

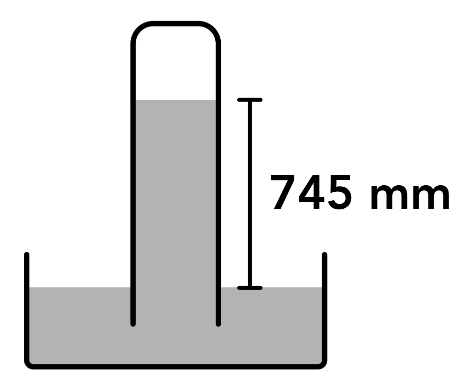

Figure 14

## Confined Fluids and Pascal's Principle

38. Pascal's principle says that…
   - **A** the pressure exerted on a surface is equal to the force exerted on the surface divided by the surface area
   - **B** the upwards force exerted on an object floating in a fluid is equal to the weight of the fluid displaced by that object
   - **C** the pressure in a fluid increases with depth due to the weight of the fluid above that point
   - **D** if we apply a change in pressure to any point in a confined fluid at rest then the pressure at every point in the fluid will change by the same amount

39. A container is partially filled with water and a square piston is placed on the top surface of the water as shown in Figure 15. If a downwards force is applied to the piston, what will happen to the force exerted by the water on the right vertical wall of the container?
   - **A** The force on that wall will increase
   - **B** The force on that wall will decrease
   - **C** The force on that wall will not change
   - **D** Cannot be determined

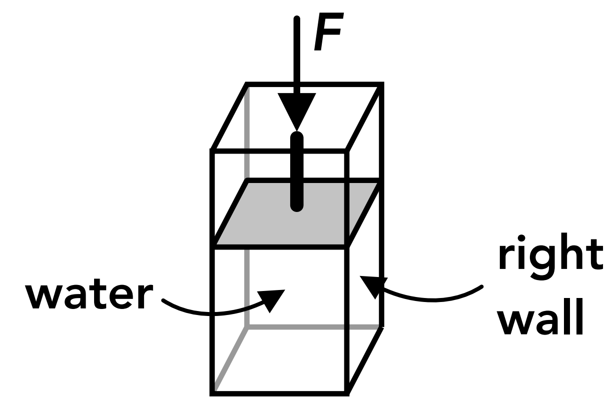

Figure 15

40. A cylinder is partially filled with mercury as shown in Figure 16. At that time the absolute pressure in the mercury at the point shown is $P_1$. A circular piston with a radius of $r$ then pushes down on the top of the mercury with a force of $F$. What is the new absolute pressure $P_2$ at that point? The density of the mercury is $\rho$.
   - **A** $\rho g h + P_{atm}$
   - **B** $P_1 + \dfrac{F}{\pi r^2}$
   - **C** $P_1 + \rho g h$
   - **D** $\dfrac{F}{\pi r^2}$

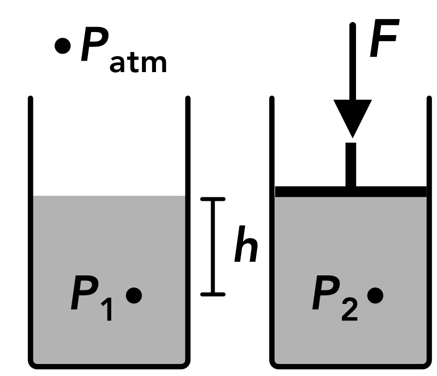

Figure 16

41. Two cylinders are connected as shown in Figure 17. If the force on the left piston is greater than the force on the right piston, how are the areas of the two pistons related?
   - **A** $A_1 > A_2$
   - **B** $A_1 = A_2$
   - **C** $A_1 < A_2$
   - **D** Cannot be determined

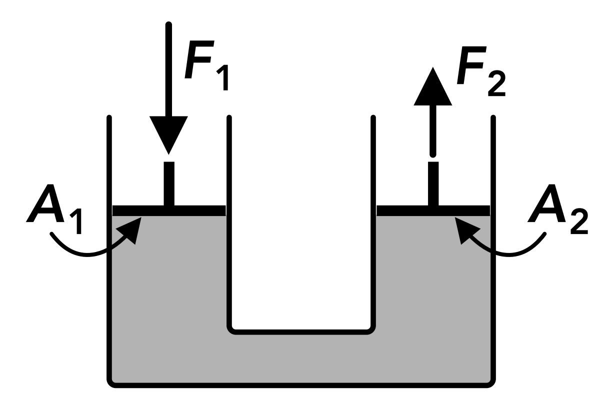

Figure 17

42. Two cylinders are connected as shown in Figure 18. What is the pressure acting on the right piston $P_2$?
   - **A** 100 kPa
   - **B** 25 kPa
   - **C** 50 kPa
   - **D** Cannot be determined

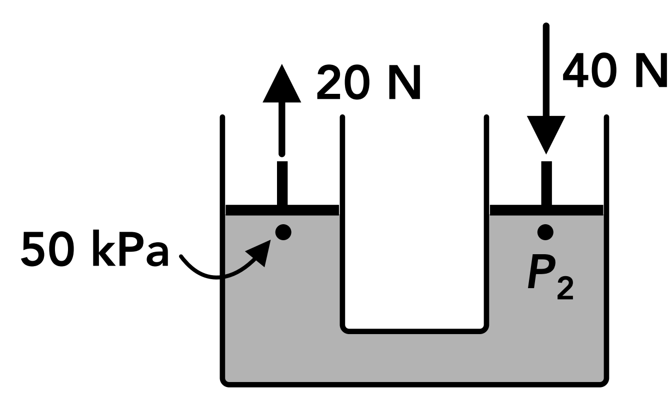

Figure 18

43. A large cylinder is connected to three smaller cylinders as shown in Figure 19. The three small pistons each have the same area and each is half of the area of the large piston on the left. How are $F_1$ and $F_2$ related?

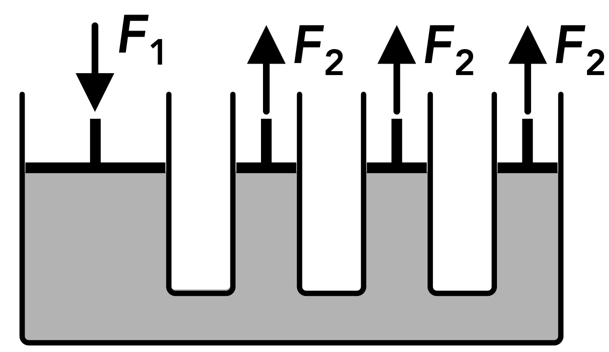

Figure 19

- A $F_2 = 2F_1$
- B $F_2 = \frac{F_1}{3}$
- C $F_2 = 3F_1$
- D $F_2 = \frac{F_1}{2}$

44. Two cylinders are connected as shown in Figure 20 and the forces acting on the two circular pistons are given. What is the radius of the left piston $r_1$?

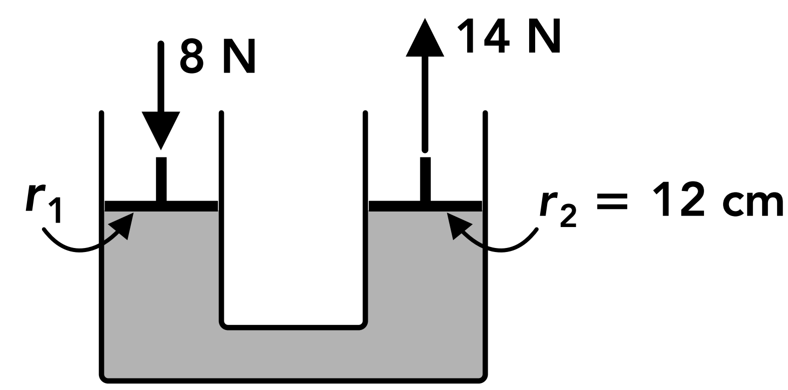

Figure 20

45. Two cylinders are connected as shown in Figure 21. The area of the right piston is three times the area of the left piston. What is the force acting on the right piston?

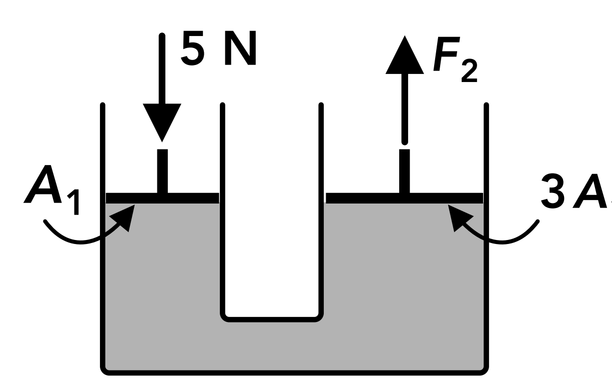

Figure 21

## Answers

| | | | | |
|---|---|---|---|---|
| 1. C | 11. 10 N | 21. 105,518 Pa | 31. D | 41. A |
| 2. B | 12. B | 22. 78,398 Pa | 32. 130,725 Pa | 42. C |
| 3. A, D | 13. C, D | 23. 0.987 atm | 33. 3.98 atm | 43. D |
| 4. A, B, C, D | 14. C | 24. A | 34. 75,419 Pa | 44. 9.1 cm |
| 5. D | 15. A | 25. C | 35. 470,400 Pa | 45. 15 N |
| 6. A | 16. False | 26. A, B, C, D | 36. 0.21 m | |
| 7. 234,422 Pa | 17. True | 27. D | 37. 99,294 Pa | |
| 8. 0.983 atm | 18. C | 28. B | 38. D | |
| 9. 30% | 19. A | 29. C | 39. A | |
| 10. 2,586 Pa | 20. 120,925 Pa | 30. A | 40. B | |

## Answers - Pressure

1. **Answer: C**
   Pressure is defined as force per unit of area.

2. **Answer: B**
   Fluid pressure is caused by the many collisions between fluid particles and between the particles and a surface. The pressure exerted on a surface by a fluid is due to the collisions between the fluid particles and the surface. This is true for fluid pressures acting on surfaces in any directions (such as a vertical wall of a fluid container) and pressure exists even if there is no weight of fluid above the container surface.

3. **Answer: A, D**
   The SI unit for pressure is the Pascal (Pa) which is equal to 1 N/m². Atmospheres (atm) is a valid unit for pressure but is not the SI unit. Kilograms per cubic meter (kg/m³) is the SI unit for density.

4. **Answer: A, B, C, D**
   All of these are valid units of pressure. 1 bar (bar) = 100,000 Pa. 1 pound per square inch (psi) is approximately equal to 6,895 Pa. 1 inch of mercury (inHg) is approximately equal to 3,386 Pa. 1 standard atmosphere (atm) is equal to 101,325 Pa.

5. **Answer: D**
   The pressure exerted on the water by the piston (and the pressure exerted on the piston by the water) is equal to the force exerted on the piston divided by the area of the piston (which is the area of a circle).

   $$P = \frac{F}{A} \qquad P = \frac{F}{\pi r^2} \qquad F = \pi r^2 P$$

6. **Answer: A**
   The pressure exerted on the bottom surface of the tank is equal to the force exerted on the surface divided by the surface area of the bottom of the tank (which is *wd*).

   $$P = \frac{F}{A} \qquad P = \frac{F}{wd}$$

7. **Answer: 234,422 Pa**
   We can convert the pressure using the unit relationship below:

   $$\frac{34 \text{ psi}}{} \times \frac{6{,}894.757 \text{ Pa}}{1 \text{ psi}} = 234{,}422 \text{ Pa}$$

8. **Answer: 0.983 atm**
We can convert the pressure using the unit relationships below:
$$\frac{29.4 \text{ inHg}}{} \times \frac{3{,}386.38 \text{ Pa}}{1 \text{ inHg}} \times \frac{1 \text{ atm}}{101{,}325 \text{ Pa}} = 0.983 \text{ atm}$$

9. **Answer: 30%**
We can convert the pressure using the unit relationship below:
$$\frac{30{,}398 \text{ Pa}}{} \times \frac{1 \text{ atm}}{101{,}325 \text{ Pa}} = 0.30 \text{ atm}$$
$$\frac{0.30 \text{ atm}}{1 \text{ atm}} \times 100\% = 30\%$$

10. **Answer: 2,586 Pa**
The pressure in the mercury at the bottom of the tube is equal to the force it exerts on the bottom surface divided by the area of the bottom surface.
$$P = \frac{F}{A} = \frac{F}{\pi r^2} = \frac{(13 \text{ N})}{\pi(0.04 \text{ m})^2} = 2{,}586 \text{ Pa}$$

11. **Answer: 10 N**
The pressure exerted on the oil by the piston is equal to the force applied to the piston divided by the area of the piston (which is a square).
$$P = \frac{F}{A} \qquad (160 \text{ Pa}) = \frac{F}{(0.25 \text{ m})(0.25 \text{ m})} \qquad F = 10 \text{ N}$$

## Answers - Absolute Pressure and Gauge Pressure

12. **Answer: B**
An absolute vacuum (also called a perfect vacuum) is when a space or container is completely empty and has no fluid particles inside of it. Without fluid particles colliding with each other and the container there is nothing that would generate pressure. A pressure that is less than atmospheric pressure is a gauge vacuum (when the gauge pressure is negative) but this is not an absolute vacuum with zero absolute pressure.

13. **Answer: C, D**
The average atmospheric pressure at sea level is 1 atm which is equal to 101,325 Pa.

14. **Answer: C**
An absolute pressure is measured relative to zero absolute pressure (an absolute vacuum).

15. **Answer: A**
A gauge pressure is measured relative to atmospheric pressure or some other reference pressure.

16. **Answer: False**
Absolute pressure is measured relative to zero absolute pressure (an absolute vacuum), so zero is the lowest possible absolute pressure.

17. **Answer: True**
Gauge pressure is measured relative to atmospheric pressure or some other reference pressure. If a pressure is lower than atmospheric pressure then the gauge pressure is negative.

18. **Answer: C**
Any liquid surface that is exposed to the atmosphere will be at atmospheric pressure at the surface. The absolute pressure of the atmosphere, and of the water at the surface, is 1 atm.

19. **Answer: A**
Any liquid surface that is exposed to the atmosphere will be at atmospheric pressure at the surface. The absolute pressure of the water at the surface is 1 atm and the gauge pressure at the surface is 0 atm (gauge pressure is equal to the absolute pressure minus the atmospheric pressure).

20. **Answer: 120,925 Pa**
The absolute pressure is the gauge pressure plus the atmospheric pressure (which we assume is 101,325 Pa).
$P_{abs} = P_{gauge} + P_{atm} = (19{,}600\text{ Pa}) + (101{,}325\text{ Pa}) = 120{,}925\text{ Pa}$

21. **Answer: 105,518 Pa**
We can convert the absolute pressure from psi to Pa:
$$\frac{30\text{ psi}}{} \times \frac{6{,}894.757\text{ Pa}}{1\text{ psi}} = 206{,}843\text{ Pa}$$
The gauge pressure is the absolute pressure minus the atmospheric pressure (which we assume is 101,325 Pa).
$P_{gauge} = P_{abs} - P_{atm} = (206{,}843\text{ Pa}) - (101{,}325\text{ Pa}) = 105{,}518\text{ Pa}$

22. **Answer: 78,398 Pa**
We can convert the atmospheric pressure from atm to Pa:
$$\frac{0.3\text{ atm}}{} \times \frac{101{,}325\text{ Pa}}{1\text{ atm}} = 30{,}398\text{ Pa}$$
The absolute pressure in the airplane is the gauge pressure plus the atmospheric pressure (which in this case is 0.3 atm or 30,398 Pa).
$P_{abs} = P_{gauge} + P_{atm} = (48{,}000\text{ Pa}) + (30{,}398\text{ Pa}) = 78{,}398\text{ Pa}$

23. **Answer: 0.987 atm**
If we assume that outer space at the altitude of the ISS is a perfect vacuum then the atmospheric pressure outside of the ISS is 0 Pa or 0 atm. The gauge pressure in the ISS is equal to the absolute pressure minus the atmospheric pressure outside (which is 0 Pa), so the gauge pressure is equal to the absolute pressure.
$P_{gauge} = P_{abs} - P_{atm} = (100{,}000\text{ Pa}) - (0\text{ Pa}) = 100{,}000\text{ Pa}$
Then we can convert the gauge pressure from Pa to atm:
$$\frac{100{,}000\text{ Pa}}{} \times \frac{1\text{ atm}}{101{,}325\text{ Pa}} = 0.987\text{ atm}$$

## Answers - Pressure and Fluid Depth

24. **Answer: A**
The pressure of a static fluid increases with depth (the pressure is higher at greater depths) due to the weight of the fluid above that point.

25. **Answer: C**
Pressure increases with depth for any fluid which includes liquids and gasses.

26. **Answer: A, B, C, D**
The equation for the absolute pressure of a fluid at a depth below the surface is shown below, where $\rho$ is the density of the fluid, $g$ is the gravitational acceleration, $h$ is the depth, and $P_{atm}$ is the atmospheric pressure.
$P_{abs} = \rho g h + P_{atm}$

27. **Answer: D**
The equation for the gauge pressure at a depth below the surface of a fluid is given below. The gauge pressure plus the atmospheric pressure gives us the absolute pressure.
$P_{gauge} = \rho gh$
$P_{abs} = \rho gh + P_{atm}$

28. **Answer: B**
The two points shown are at the same height in the same fluid so the pressure at each point is the same.

29. **Answer: C**
The equation for the difference in pressure between two depths in a fluid is given below. The absolute pressure of $P_2$ is the absolute pressure of $P_1$ plus the additional pressure due to the change in depth which is $\rho g\Delta h$.
$\Delta P = P_2 - P_1 = \rho g\Delta h$ $\quad P_2 - (111{,}000 \text{ Pa}) = \rho g\Delta h$ $\quad P_2 = 111{,}000 \text{ Pa} + \rho g\Delta h$

30. **Answer: A**
The two points shown are at the same height in the same fluid so the pressure at each point is the same.

31. **Answer: D**
The points are all in the same fluid and the shape of the container does not affect the pressure. Points A and B are at the same height so they are at the same pressure. Points C and D are at the same height so they are at the same pressure. Pressure increases with depth so the pressure at C and D are greater than at A and B.

32. **Answer: 130,725 Pa**
The equation for the absolute pressure at a fluid depth is given below. The density of water is 1,000 kg/m³.
$P_{abs} = \rho gh + P_{atm} = (1{,}000 \text{ kg/m}^3)g(3 \text{ m}) + (101{,}325 \text{ Pa}) = 130{,}725 \text{ Pa}$

33. **Answer: 3.98 atm**
First we can use the equation for the gauge pressure at a depth in a fluid:
$P_{gauge} = \rho gh = (1{,}030 \text{ kg/m}^3)g(40 \text{ m}) = 403{,}760 \text{ Pa}$
Then we can conver the pressure from Pa to atm:
$$\frac{403{,}760 \text{ Pa}}{} \times \frac{1 \text{ atm}}{101{,}325 \text{ Pa}} = 3.98 \text{ atm}$$

34. **Answer: 75,419 Pa**
The atmospheric pressure is 72% of the atmospheric pressure at sea level (1 atm or 101,325 Pa):
$P_{atm} = (0.72)(101{,}325 \text{ Pa}) = 72{,}954 \text{ Pa}$
Then we can find the absolute pressure at a depth of 25 cm in the coffee:
$P_{abs} = \rho gh + P_{atm} = (1{,}006 \text{ kg/m}^3)g(0.25 \text{ m}) + (72{,}954 \text{ Pa}) = 75{,}419 \text{ Pa}$

35. **Answer: 470,400 Pa**
The point where the pipe enters the home, which is at ground level, is at a depth of 48 m below the surface of the water in the water tower (the fact that the pipe goes below the ground and back up does not change the pressure at a point below the surface). The gauge pressure in the water at that depth is:
$P_{gauge} = \rho gh = (1{,}000 \text{ kg/m}^3)g(48 \text{ m}) = 470{,}400 \text{ Pa}$

36. **Answer: 0.21 m**
The pressure at the top surface of a liquid is equal to the atmospheric or air pressure above the surface. The pressure at the surface of the water on the left side is equal to atmospheric pressure (1 atm or 101,325 Pa) and the pressure at the surface of the water on the right side is equal to the air pressure in the balloon (103,400 Pa). We also know that two points at the same height in the same fluid will be at the same pressure, so a point in the water on the left side of the tube which is at the same height as the surface on the right will also be at the same pressure as the balloon (103,400 Pa). That pressure is related to the depth below the surface on the left side of the tube (the depth is $\Delta h$). For the point at a depth of $\Delta h$ on the left side of the tube:
$P_{abs} = \rho g h + P_{atm}$ $\quad (103{,}400 \text{ Pa}) = (1{,}000 \text{ kg/m}^3) g \Delta h + (101{,}325 \text{ Pa})$ $\quad \Delta h = 0.21 \text{ m}$

37. **Answer: 99,294 Pa**
The upper surface of the mercury inside the center tube is at a pressure of 0 Pa because the space above the mercury in the tube is considered an absolute vacuum. The surface of the mercury in the bottom section is exposed to the atmosphere so it is at atmospheric pressure (which we are trying to find). The pressure at a point in the mercury in the tube which is at the same height as the mercury surface exposed to the atmosphere must also be at atmospheric pressure (two points at the same height in the same fluid have the same pressure). We can find the difference in pressure between the vacuum at the top surface and the pressure at that depth (which is equal to the atmospheric pressure):
$\Delta P = P_{bottom} - P_{top} = \rho g \Delta h$ $\quad P_{bottom} - (0 \text{ Pa}) = (13{,}600 \text{ kg/m}^3) g (0.745 \text{ m})$ $\quad P_{bottom} = P_{atm} = 99{,}294 \text{ Pa}$

## Answers - Confined Fluids and Pascal's Principle

38. **Answer: D**
Pascal's principle says that if we apply a change in pressure to any point in a confined fluid at rest then the pressure at every point in the fluid will change by the same amount. We could say that the pressure change is "distributed" throughout the fluid in all directions.

39. **Answer: A**
The pressure in a fluid acts in all directions and the force exerted by a fluid on a surface acts perpendicular to the surface. The water exerts a horizontal force on the right wall of the container. When the piston is pushed down the pressure everywhere in the water increases and the force on the right wall also increases (the force on every surface of the container that is in contact with the water increases).

40. **Answer: B**
The pressure at the point shown (and at every point in the mercury) increases by the amount of pressure exerted on the mercury by the piston, which is equal to the piston force divided by the piston area (a circle).

$$P_2 = P_1 + P_{piston} = P_1 + \frac{F}{\pi r^2}$$

41. **Answer: A**
We assume the pressure acting on each piston is the same (we assume the pistons are at the same height) so the two forces and areas are related as shown below. If $F_1$ is greater than $F_2$ then $A_1$ must be greater than $A_2$ if the pressures are equal.

$$P = \frac{F}{A} \qquad P_1 = P_2 \qquad \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

42. **Answer: C**
We assume the pressure acting on each piston is the same (we assume the pistons are at the same height) so $P_1 = P_2 = 50$ kPa.

43. **Answer: D**

We assume the pressure acting on each piston is the same (we assume the pistons are at the same height). The areas of the three smaller pistons are equal to each other, and each one has half of the area of the large piston on the left. The forces and areas are related as shown below.

$$P_2 = P_1 \qquad \frac{F_2}{A_2} = \frac{F_1}{A_1} \qquad F_2 = \frac{F_1}{A_1}A_2 = \frac{F_1}{A_1}\frac{A_1}{2} = \frac{F_1}{2}$$

44. **Answer: 9.1 cm**

We assume the pressure acting on each piston is the same (we assume the pistons are at the same height) so the forces and areas are related as shown below.

$$P_1 = P_2 \qquad \frac{F_1}{A_1} = \frac{F_2}{A_2} \qquad \frac{(8\text{ N})}{\pi r_1^2} = \frac{(14\text{ N})}{\pi(0.12\text{ m})^2} \qquad r_1 = 9.1\text{ cm}$$

45. **Answer: 15 N**

We assume the pressure acting on each piston is the same (we assume the pistons are at the same height) so the forces and areas are related as shown below.

$$P_2 = P_1 \qquad \frac{F_2}{A_2} = \frac{F_1}{A_1} \qquad F_2 = \frac{F_1}{A_1}A_2 = \frac{F_1}{A_1}(3A_1) = 3F_1 = 3(5\text{ N}) = 15\text{ N}$$