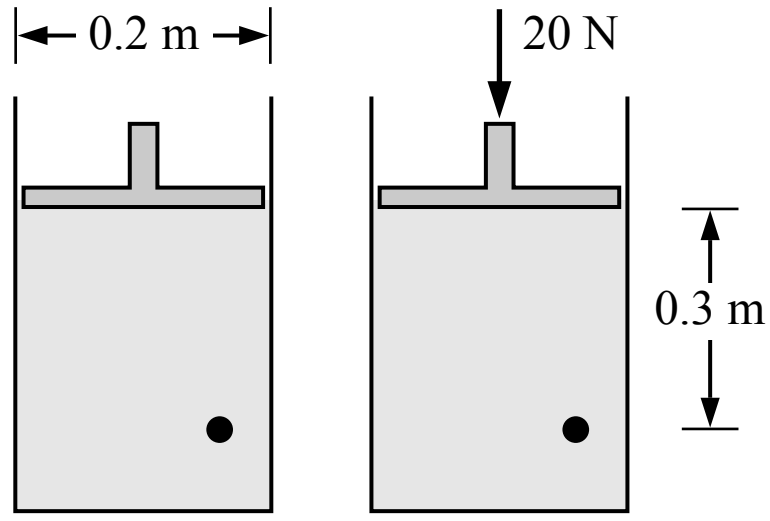
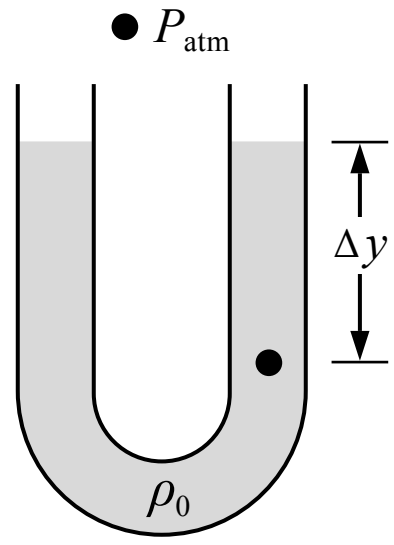
PRESSURE



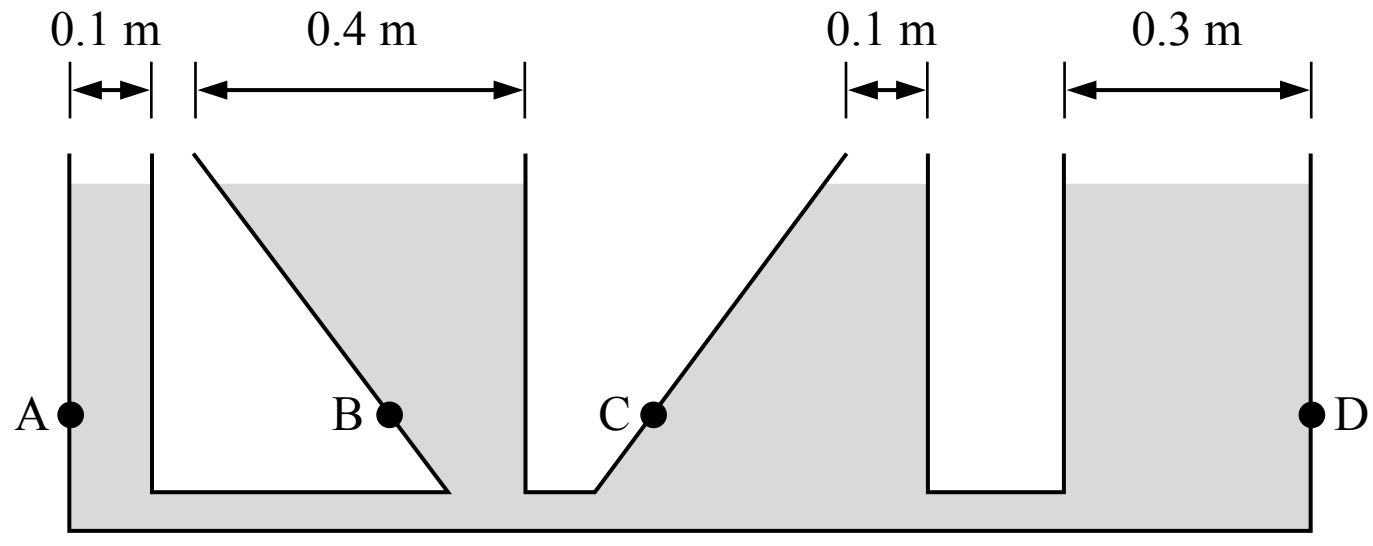
1. A volume of water is contained in a cylinder below a piston as shown in the figure above. The diameter of the circular piston is 0.2 m. A force of 20 N is then applied to the piston. What is the change in pressure at the point shown, 0.3 m below the piston, when the 20 N force is applied? The density of the water is 1,000 kg/m³.

   (A) 159 Pa
   (B) 3,000 Pa
   (C) 637 Pa
   (D) 3,637 Pa



2. A tube is partially filled with a liquid with a density of ρ_0 as shown in the figure above. The ends of the tube are open. Which of the following is a correct expression for the absolute pressure at the point shown in the liquid?

   (A) $\rho_0 g \Delta y$
   (B) $P_{atm} - \rho_0 g \Delta y$
   (C) $\rho_0 g \Delta y - P_{atm}$
   (D) $\rho_0 g \Delta y + P_{atm}$



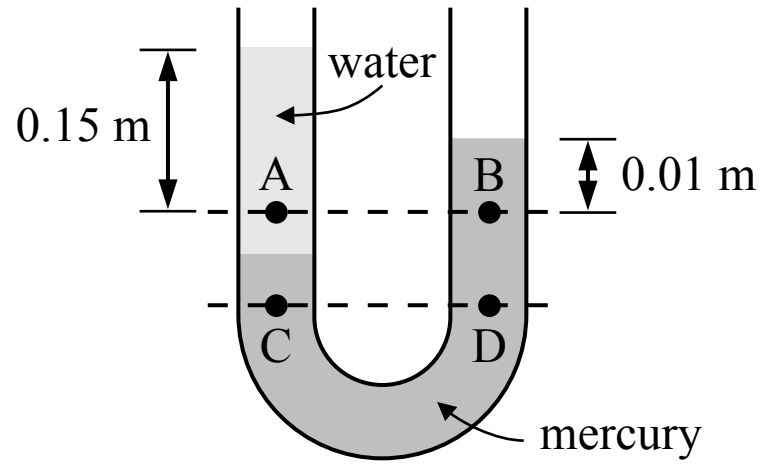
3. A large container is mostly filled with a liquid and is open at the top as shown in the figure above. The four points shown are at the same height above the bottom of the container. Which of the following correctly ranks the pressure exerted on the wall of the container by the liquid at the four points shown?

(A) $P_A = P_B = P_C = P_D$

(B) $(P_A = P_C) < P_D < P_B$

(C) $P_B < P_D < (P_A = P_C)$

(D) $P_C < (P_A = P_D) < P_B$



Note: Figure not drawn to scale.

4. A tube contains a volume of water and a volume of mercury as shown in the figure above. Both ends of the tube are open. Points A and B are at the same level and points C and D are at the same level. The distance between points A and B and the surface of the liquids are shown. Which of the following correctly relates the gauge pressures at the points shown? The density of the water is 1,000 kg/m³ and the density of the mercury is 13,600 kg/m³.

(A)

P_A and P_B	P_C and P_D
$P_A > P_B$	$P_C > P_D$

(B)

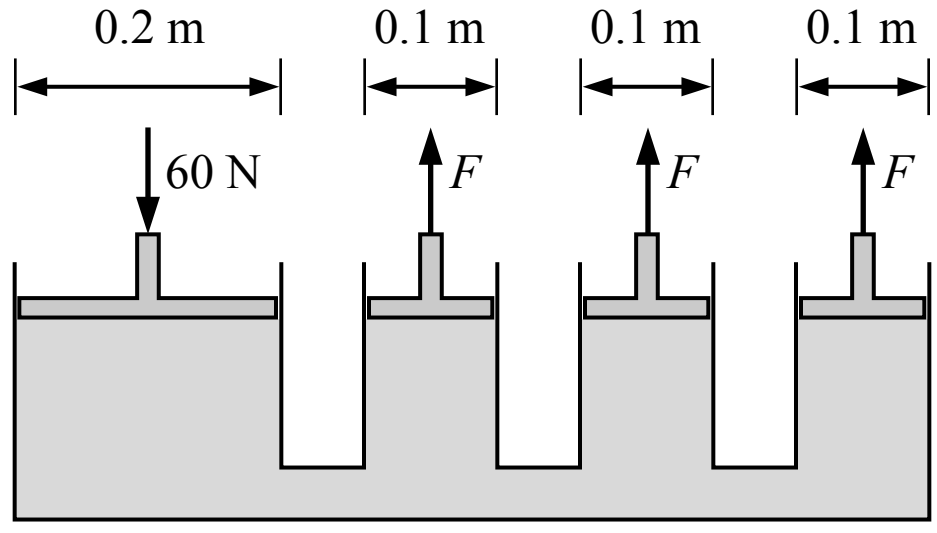
P_A and P_B	P_C and P_D
$P_A > P_B$	$P_C = P_D$

(C)

P_A and P_B	P_C and P_D
$P_A = P_B$	$P_C = P_D$

(D)

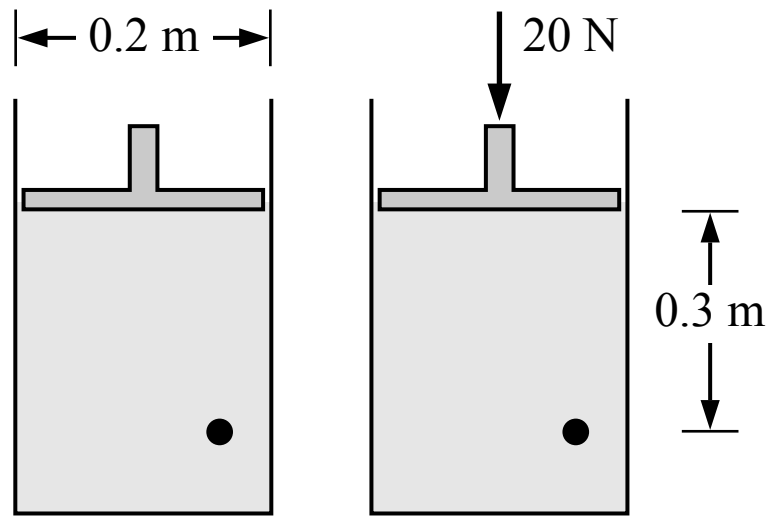
P_A and P_B	P_C and P_D
$P_A = P_B$	$P_C > P_D$



Note: Figure not drawn to scale.

5. A series of square tubes are connected and filled with liquid as shown in the figure above. The area of each piston is a square and the side lengths of the pistons are shown. When a 60 N force is applied to the left piston, what is the magnitude of the force exerted on each of the three right pistons, F?

(A) 30 N
(B) 20 N
(C) 60 N
(D) 15 N



1. A volume of water is contained in a cylinder below a piston as shown in the figure above. The diameter of the circular piston is 0.2 m. A force of 20 N is then applied to the piston. What is the change in pressure at the point shown, 0.3 m below the piston, when the 20 N force is applied? The density of the water is 1,000 kg/m³.

   (A) 159 Pa

   (B) 3,000 Pa

   (C) 637 Pa

   (D) 3,637 Pa

A Incorrect

This answer incorrectly uses 0.2 m for the radius of the piston.

B Incorrect

This is the pressure at the point shown only due to its depth (due to the weight of the water above it). It is not the change in pressure at that point when the piston force is applied.

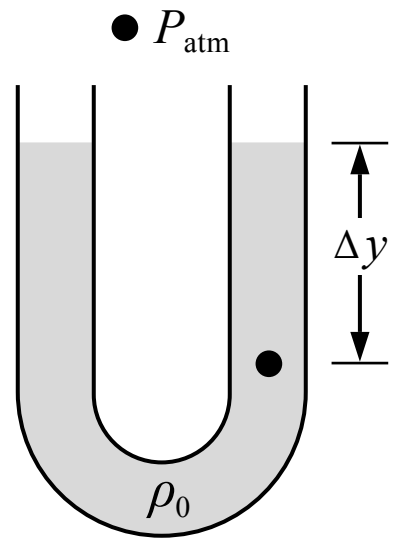
C **Correct**

When the force is applied to the piston the pressure at every point in the water changes by the same amount (Pascal's principle) including at the point shown. The change in pressure caused by the force on the piston is equal to the piston force divided by the piston area.

$$\Delta P = P_{\text{piston}} = \frac{F}{A} = \frac{F}{\pi r^2} = \frac{(20\text{ N})}{\pi(0.1\text{ m})^2} = 637\text{ Pa}$$

D Incorrect

This is the total gauge pressure at the point shown (the sum of the pressure due to its depth and the pressure applied by the piston). It is not the change in pressure at that point when the piston force is applied.



2. A tube is partially filled with a liquid with a density of ρ_0 as shown in the figure above. The ends of the tube are open. Which of the following is a correct expression for the absolute pressure at the point shown in the liquid?

(A) $\rho_0 g \Delta y$

(B) $P_{atm} - \rho_0 g \Delta y$

(C) $\rho_0 g \Delta y - P_{atm}$

(D) $\rho_0 g \Delta y + P_{atm}$

A Incorrect

This is the gauge pressure at the point shown due to the weight of the liquid above it. The absolute pressure is the gauge pressure plus the atmospheric pressure.

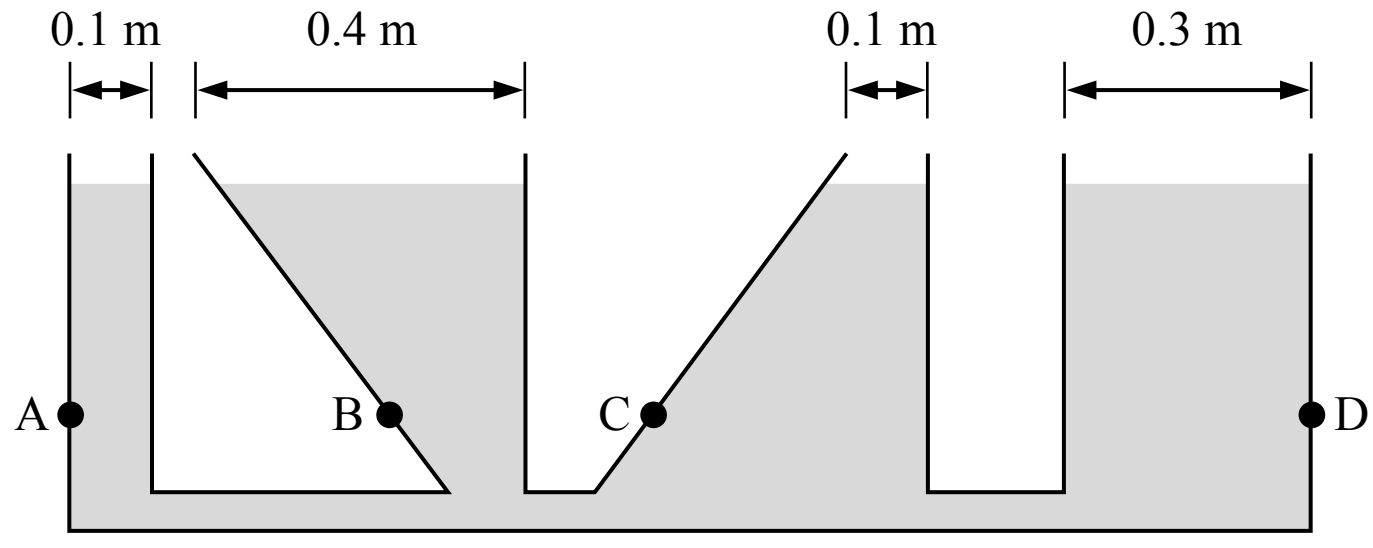
B Incorrect

C Incorrect

D Correct

The absolute pressure at a point in a fluid is equal to the gauge pressure plus the atmospheric pressure. The gauge pressure at a point below the surface of a fluid depends on the density of the fluid and the depth.

$P_{abs} = P_{gauge} + P_{atm} = \rho g h + P_{atm} = \rho_0 g \Delta y + P_{atm}$



3. A large container is mostly filled with a liquid and is open at the top as shown in the figure above. The four points shown are at the same height above the bottom of the container. Which of the following correctly ranks the pressure exerted on the wall of the container by the liquid at the four points shown?

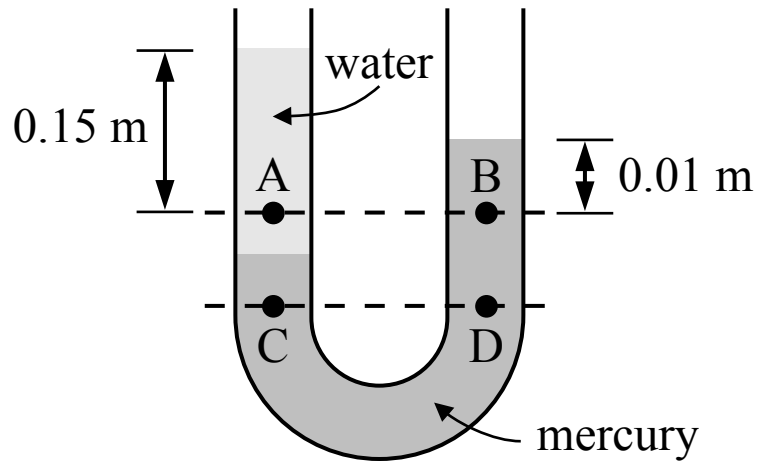
(A) $P_A = P_B = P_C = P_D$
(B) $(P_A = P_C) < P_D < P_B$
(C) $P_B < P_D < (P_A = P_C)$
(D) $P_C < (P_A = P_D) < P_B$

A **Correct**
Every point in the same fluid that is at the same level (height) is at the same pressure, so the pressure exerted on the walls at those points are the same. The shape of the container does not matter.

B Incorrect
This answer may have been found by incorrectly ranking the pressures based on the widths of the openings above those points, but that does not affect the pressures.

C Incorrect
This is the reverse ranking of option B which may have been found by incorrectly ranking the pressures based on the widths of the openings, but that does not affect the pressures.

D Incorrect
This answer may have been found by incorrectly assuming the slope of the wall and the direction of the pressure affects the magnitude of the pressure. The pressure at a point in a fluid acts equally in all directions.



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4. A tube contains a volume of water and a volume of mercury as shown in the figure above. Both ends of the tube are open. Points A and B are at the same level and points C and D are at the same level. The distance between points A and B and the surface of the liquids are shown. Which of the following correctly relates the gauge pressures at the points shown? The density of the water is 1,000 kg/m³ and the density of the mercury is 13,600 kg/m³.

(A)

P_A and P_B	P_C and P_D
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(B)

P_A and P_B	P_C and P_D
$P_A > P_B$	$P_C = P_D$

(C)

P_A and P_B	P_C and P_D
$P_A = P_B$	$P_C = P_D$

(D)

P_A and P_B	P_C and P_D
$P_A = P_B$	$P_C > P_D$

A Incorrect

B Correct

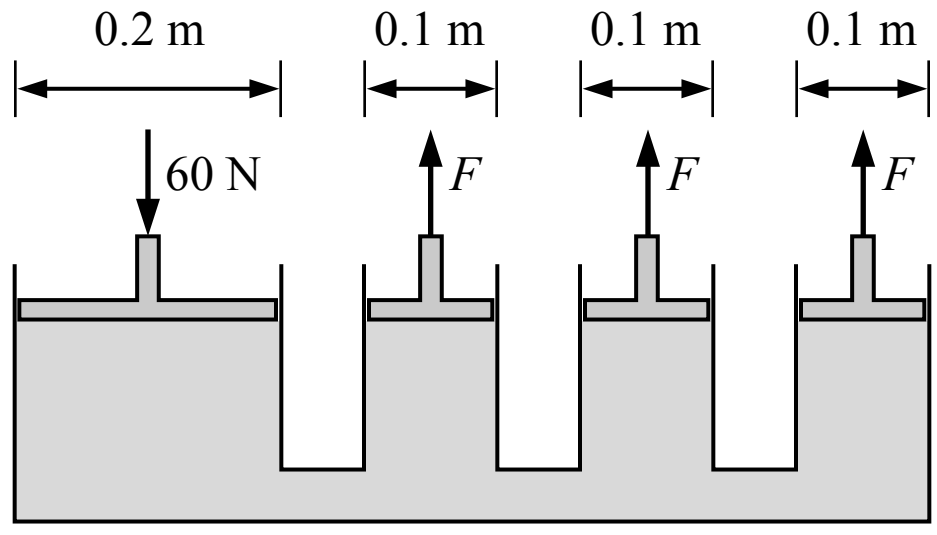
The pressure at two points that are at the same level in the same fluid are at the same pressure. Points C and D are both in the mercury at the same level so they are at the same pressure. Points A and B are in different fluids so they are not necessarily at the same pressure. We are given the depth of each point below the surfaces of the fluids which are exposed to the atmosphere, so we can calculate the gauge pressure of points A and B and compare them.

$P_A = \rho g h = (1{,}000\ \text{kg/m}^3) g (0.15\ \text{m}) = 1{,}500\ \text{Pa}$

$P_B = \rho g h = (13{,}600\ \text{kg/m}^3) g (0.01\ \text{m}) = 1{,}360\ \text{Pa}$

C Incorrect

D Incorrect



Note: Figure not drawn to scale.

5. A series of square tubes are connected and filled with liquid as shown in the figure above. The area of each piston is a square and the side lengths of the pistons are shown. When a 60 N force is applied to the left piston, what is the magnitude of the force exerted on each of the three right pistons, F?

(A) 30 N
(B) 20 N
(C) 60 N
(D) 15 N

A Incorrect
This answer may have been found by incorrectly assuming the force on a small piston is half of the force on the large piston because the width of the small piston is half of the width of the large piston. However the forces are related by the piston areas, not the widths.

B Incorrect
This answer may have been found by incorrectly assuming the 60 N force is evenly divided among the three other pistons.

C Incorrect
This answer may have been found by incorrectly assuming the forces on each piston are the same. The pressures on each piston are the same but the forces are not the same because the piston areas are different.

D Correct
We assume the pistons are at the same height and that the pressure exerted on each piston by the liquid is the same. The pressure acting on the left piston is equal to the pressure acting on one of the right pistons.

$$P_1 = P_2 \qquad \frac{F_1}{A_1} = \frac{F_2}{A_2} \qquad \frac{(60\text{ N})}{(0.2\text{ m})^2} = \frac{F}{(0.1\text{ m})^2} \qquad F = 15\text{ N}$$