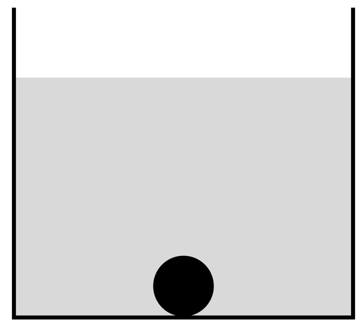
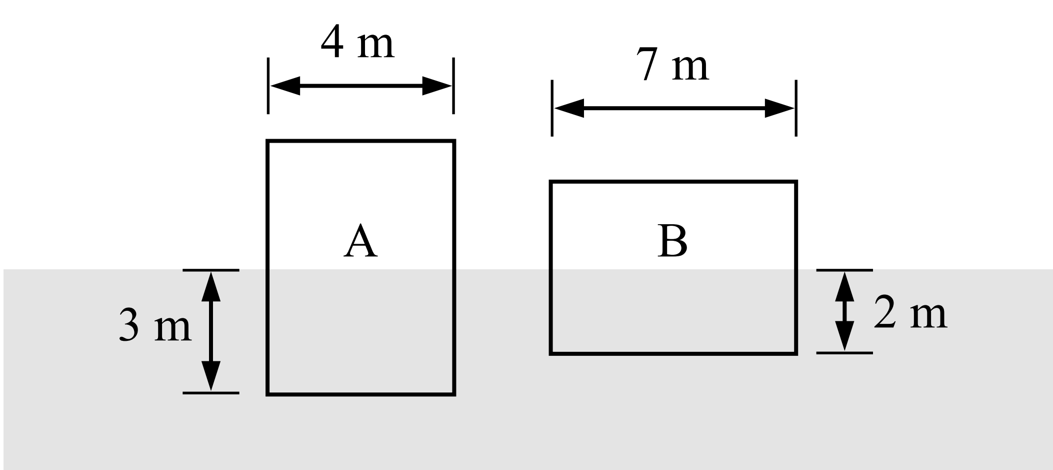
BUOYANT FORCE



1. A ball is dropped into a container of liquid and it sinks to the bottom as shown in the figure above. Which of the following statements is true about the forces acting on the ball?

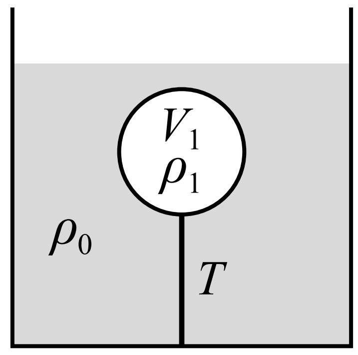
(A) The magnitude of the buoyant force acting on the ball is less than the weight of the ball but not zero
(B) The magnitude of the buoyant force acting on the ball is equal to the weight of the ball
(C) The magnitude of the buoyant force acting on the ball is greater than the weight of the ball
(D) The magnitude of the buoyant force acting on the ball is zero



Note: Figure not drawn to scale.

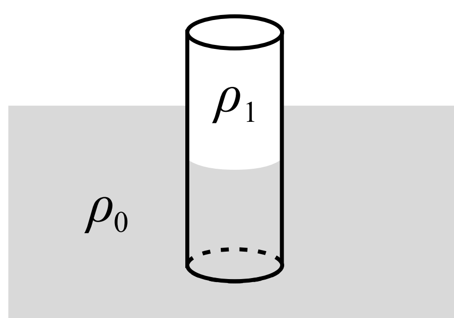
2. Two solid blocks are partially submerged and floating at rest in a liquid as shown in the figure above. The blocks have the same thickness (the dimension into/out of the page). Which of the two blocks has a greater mass?

(A) Block A
(B) Block B
(C) They have the same mass
(D) Cannot be determined



3. A ball is submerged and floating at rest in a liquid as shown in the figure above. The ball is attached to the bottom of the container by a string. The density of the liquid is ρ_0 , the density of the ball is ρ_1 and the volume of the ball is V_1 . Which of the following is a correct expression for the tension in the string T ?

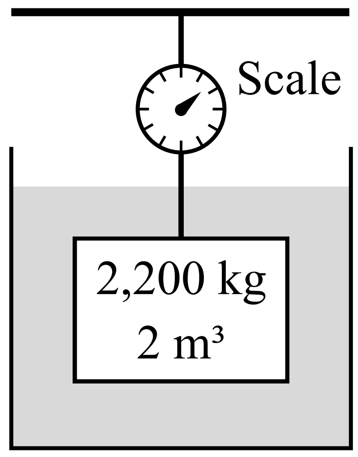
(A) $\rho_1 V_1 g + \rho_0 V_1 g$
(B) $\rho_1 V_1 g - \rho_0 V_1 g$
(C) $\rho_0 V_1 g - \rho_1 V_1 g$
(D) $\rho_0 V_1 g$



Note: Figure not drawn to scale.

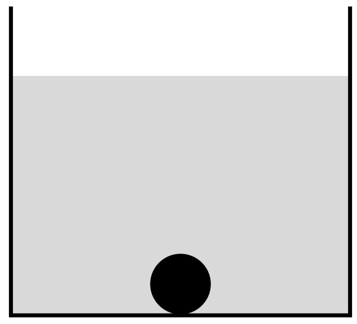
4. A solid cylinder is floating partially submerged in a liquid as shown in the figure above. The density of the liquid ρ_0 is 1,100 kg/m³ and the density of the cylinder ρ_1 is 900 kg/m³. The percent of the cylinder's volume that is below the surface of the liquid is most nearly

(A) 22%
(B) 82%
(C) 18%
(D) 90%



5. A block is suspended from a scale with a string and is fully submerged in a container of water as shown in the figure above. The block has a mass of 2,200 kg and a volume of 2 m^3. The density of the water is 1,000 kg/m^3. The reading on the scale is

(A) 20,000 N
(B) 22,000 N
(C) 0 N
(D) 2,000 N



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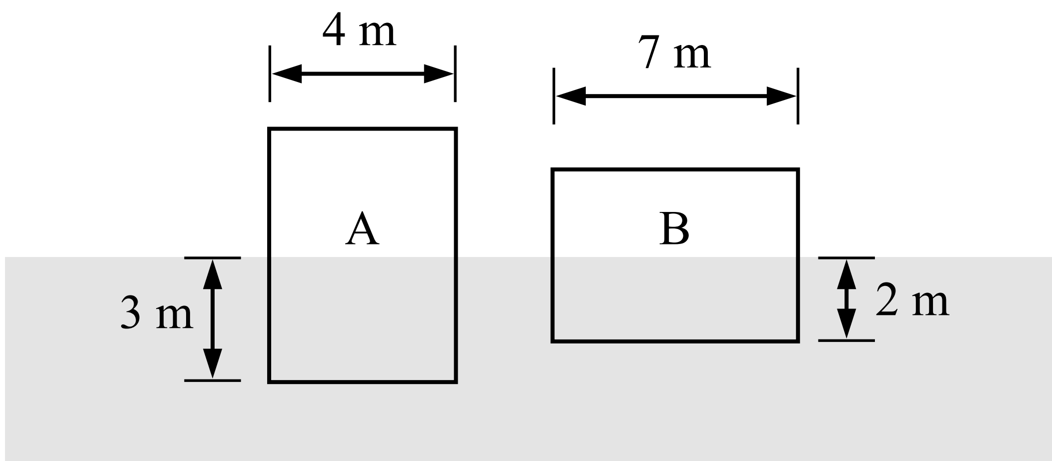
(B) The magnitude of the buoyant force acting on the ball is equal to the weight of the ball
(C) The magnitude of the buoyant force acting on the ball is greater than the weight of the ball
(D) The magnitude of the buoyant force acting on the ball is zero

A **Correct**
The ball is submerged in a fluid so there is an upwards buoyant force acting on the ball due to the fluid, and there is a downwards weight force acting on the ball. The ball sank in the fluid so the weight force is greater than the buoyant force (if the buoyant force was equal to the weight force the ball would float). When the ball is at rest on the bottom of the container the weight force is equal to the buoyant force plus the normal force.

B Incorrect

C Incorrect

D Incorrect



Note: Figure not drawn to scale.

2. Two solid blocks are partially submerged and floating at rest in a liquid as shown in the figure above. The blocks have the same thickness (the dimension into/out of the page). Which of the two blocks has a greater mass?

(A) Block A

(B) Block B

(C) They have the same mass

(D) Cannot be determined

A Incorrect

B **Correct**

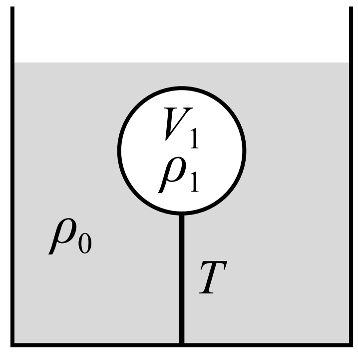
Each block is at rest so the net force on the block is zero (Newton's 1st law), and the upwards buoyant force on a block is equal to the downwards weight force on the block. We can simplify that equation to get an expression for the mass of each block in terms of the width, depth below the surface, thickness t and fluid density ρ_f and then compare the masses. Block B displaces more fluid volume so it has a greater mass.

Block A: $\Sigma F_y = F_B - F_g = 0 \quad F_g = F_B \quad mg = \rho_f V_f g \quad m = \rho_f V_f = \rho_f (4\text{ m})(3\text{ m})t = (12\text{ m}^2)\rho_f t$

Block B: $\Sigma F_y = F_B - F_g = 0 \quad F_g = F_B \quad mg = \rho_f V_f g \quad m = \rho_f V_f = \rho_f (7\text{ m})(2\text{ m})t = (14\text{ m}^2)\rho_f t$

C Incorrect

D Incorrect



3. A ball is submerged and floating at rest in a liquid as shown in the figure above. The ball is attached to the bottom of the container by a string. The density of the liquid is ρ_0 , the density of the ball is ρ_1 and the volume of the ball is V_1 . Which of the following is a correct expression for the tension in the string T ?

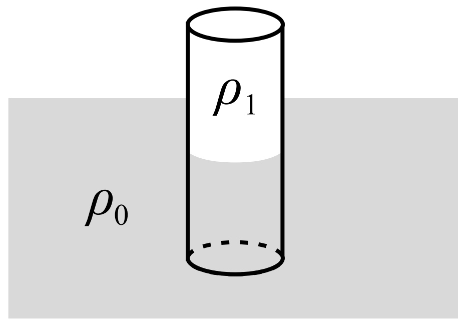
(A) $\rho_1 V_1 g + \rho_0 V_1 g$
(B) $\rho_1 V_1 g - \rho_0 V_1 g$
(C) $\rho_0 V_1 g - \rho_1 V_1 g$
(D) $\rho_0 V_1 g$

A Incorrect

B Incorrect
This answer incorrectly assumes the tension force on the ball is acting upwards instead of downwards.

C **Correct**
The ball is at rest so the net force on the ball is zero (Newton's 1st law). There is an upwards buoyant force, a downwards tension force and a downwards weight force acting on the ball. We can replace the mass of the ball with its density multiplied by its volume.
$\Sigma F_y = F_B - F_g - T = 0 \qquad T = F_B - F_g = \rho_f V_f g - mg = \rho_0 V_1 g - \rho_1 V_1 g$

D Incorrect
This is the upwards buoyant force acting on the ball.



Note: Figure not drawn to scale.

4. A solid cylinder is floating partially submerged in a liquid as shown in the figure above. The density of the liquid ρ_0 is 1,100 kg/m³ and the density of the cylinder ρ_1 is 900 kg/m³. The percent of the cylinder's volume that is below the surface of the liquid is most nearly

   (A) 22%
   (B) 82%
   (C) 18%
   (D) 90%

A Incorrect

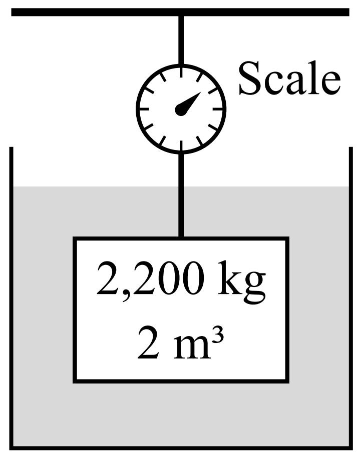
B **Correct**
We assume the cylinder is floating at rest so the net force on the cylinder is zero (Newton's 1st law), so the upwards buoyant force is equal to the downwards weight force on the cylinder. We can replace the mass of the cylinder with its density ρ_1 multiplied by its total volume V_1. Then we can calculate the percent of the cylinder's total volume V_1 that is below the surface, V_f (the volume of fluid displaced by the cylinder).

$\Sigma F_y = F_B - F_g = 0 \qquad F_B = F_g \qquad \rho_f V_f g = mg \qquad \rho_0 V_f g = \rho_1 V_1 g$

$$\frac{V_f}{V_1} = \frac{\rho_1}{\rho_0} = \frac{900\ \text{kg/m}^3}{1{,}100\ \text{kg/m}^3} = 0.82 = 82\%$$

C Incorrect

D Incorrect



5. A block is suspended from a scale with a string and is fully submerged in a container of water as shown in the figure above. The block has a mass of 2,200 kg and a volume of 2 m^3. The density of the water is 1,000 kg/m^3. The reading on the scale is

(A) 20,000 N

(B) 22,000 N

(C) 0 N

(D) 2,000 N

A Incorrect
This is the magnitude of the buoyant force on the block.

B Incorrect
This is the weight of the block. The tension in the string (and the reading on the scale) is not equal to the weight of the block because there is also an upwards buoyant force on the block.

C Incorrect
This answer may have been found by incorrectly assuming the upwards buoyant force on the block is equal to the weight of the block, or by using the density of the block instead of the density of the fluid to calculate the buoyant force.

D **Correct**
We assume the block is at rest because we are not told otherwise, and the density of the block is greater than the density of the water so the block does not float upwards. If the block is at rest then the net force on the block is zero (Newton's 1st law). There is an upwards buoyant force, a downwards weight force and an upwards tension force on the block from the string. The scale reads the tension force in the string.

$\Sigma F_y = F_B - F_g + T = 0 \qquad T = F_g - F_B = mg - \rho_f V_f g = (2{,}200 \text{ kg})g - (1{,}000 \text{ kg/m}^3)(2 \text{ m}^3)g = 2{,}000 \text{ N}$