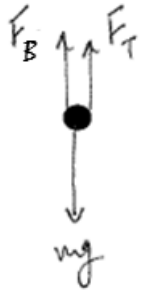
# AP® PHYSICS B
# 2013 SCORING GUIDELINES

## Question 1

**10 points total** **Distribution of points**

(a) 3 points




For showing the buoyant force in the correct direction and labeling it — 1 point
For showing the tension in the correct direction and labeling it — 1 point
For showing the gravitational force in the correct direction and labeling it — 1 point
One earned point was deducted for any extraneous forces.

(b) 2 points

For use of the correct expression for the buoyant force — 1 point

$F_B = \rho V g$

Substitute correct values

$F_B = \left(1000 \text{ kg/m}^3\right)\left(6.25 \times 10^{-3} \text{ m}^3\right)\left(9.8 \text{ m/s}^2\right)$

For a correct answer, with units — 1 point

$F_B = 61.3 \text{ N}$ (62.5 N if using $g = 10 \text{ m/s}^2$)

(c) 3 points

For a correct expression of Newton's second law when the anchor is at equilibrium — 1 point

$F_T + F_B = mg$

For substituting a value consistent with the buoyant force from part (b) — 1 point

For substituting correct values for calculation of the gravitational force — 1 point

$F_T = (50 \text{ kg})\left(9.8 \text{ m/s}^2\right) - (61.3 \text{ N})$

$F_T = 429 \text{ N}$ (438 N if using $g = 10 \text{ m/s}^2$)

**Question 1 (continued)**

**Distribution of points**

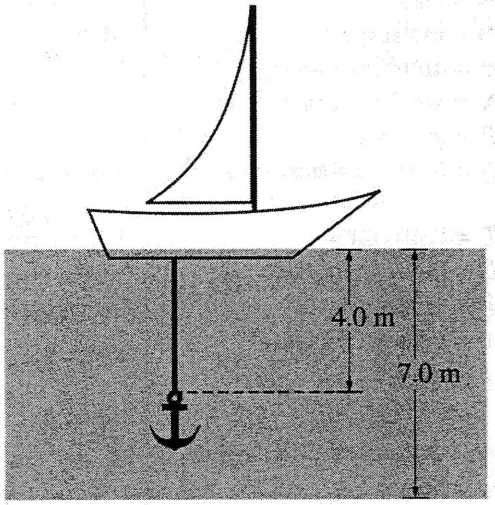
(d) 2 points

For selecting $d' > d$ 1 point
For a correct justification 1 point

Example
When the anchor is lifted onto the boat, the buoyant force on the boat must now support the weight of both the boat and the anchor. This will increase the buoyant force, which requires a greater volume of water, which means the boat will reach a greater depth into the water.

**PHYSICS B**
**SECTION II**
**Time—90 minutes**
**7 Questions**

**Directions:** Answer all seven questions, which are weighted according to the points indicated. The suggested times are about 11 minutes for answering each of Questions 1, 3-5 and 7 and about 17 minutes for answering each of Questions 2 and 6. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.




1. (10 points)

A sailboat at rest on a calm lake has its anchor dropped a distance of 4.0 m below the surface of the water. The anchor is suspended by a rope of negligible mass and volume. The mass of the anchor is 50 kg, and its volume is $6.25 \times 10^{-3}$ $m^3$. The density of water is 1000 $kg/m^3$.

(a) On the dot below that represents the anchor, draw and label the forces (not components) that act on the anchor.

(b) Calculate the magnitude of the buoyant force acting on the anchor. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. DO NOT add anything to the figure in part (a).

$F_B = \rho V_g$

$F_B = 1000(6.25\times10^{-3})(9.8)$

$= 6.25(9.8)$

$= 61.25N$

(c) Calculate the tension in the rope. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. DO NOT add anything to the figure in part (a).

$F_T + F_B = mg$

$F_T = mg - F_B$

$F_T = 50(9.8) - 61.25$

$F_T = 428.75N$

(d) The bottom of the boat is at a depth $d$ below the surface of the water. Suppose the anchor is lifted back into the boat so that the bottom of the boat is at a new depth $d'$ below the surface of the water. How does $d'$ compare to $d$ ?

____ $d' < d$ ____ $d' = d$ ✓ $d' > d$

Justify your answer.

This is true because less mass will be submerged so the Buoyant Force will have less lift causing the boat to sink over so slightly.

**PHYSICS B**
**SECTION II**
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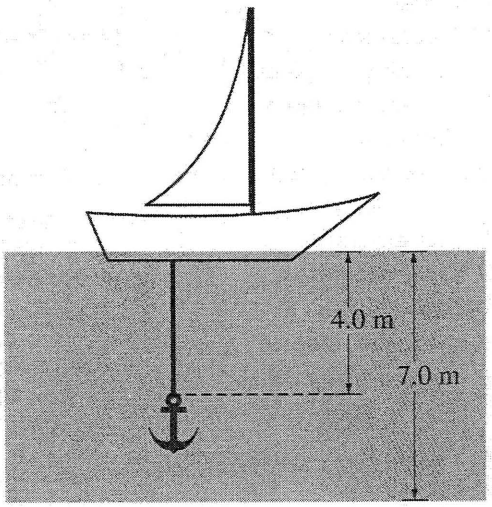


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(a) On the dot below that represents the anchor, draw and label the forces (not components) that act on the anchor.

(b) Calculate the magnitude of the buoyant force acting on the anchor. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. DO NOT add anything to the figure in part (a).

$F_{buoy} = \rho V g$ $\quad V = 6.25 \times 10^{-3}\ m^3$ $\quad \rho = 1000\ kg/m^3$

$F_{buoy} = (1000\ kg/m^3)(6.25 \times 10^{-3}\ m^3)(9.8\ m/s^2)$

$F_{buoy} = 61.25\ N$

(c) Calculate the tension in the rope. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. DO NOT add anything to the figure in part (a).

$F_T - F_{buoy} = ma$

$F_T = ma + F_{buoy}$

$F_T = (50\ kg)(9.8\ m/s^2) + 61.25\ N$

$F_T = 551.25\ N$

(d) The bottom of the boat is at a depth $d$ below the surface of the water. Suppose the anchor is lifted back into the boat so that the bottom of the boat is at a new depth $d'$ below the surface of the water. How does $d'$ compare to $d$?

✓ $d' < d$ ____ $d' = d$ ____ $d' > d$

Justify your answer.

Once the anchor is lifted, there is no buoyant force that is holding on to the boat. When the anchor is lifted, the boat rises back up, instead of being tied down.

**PHYSICS B**
**SECTION II**
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**7 Questions**

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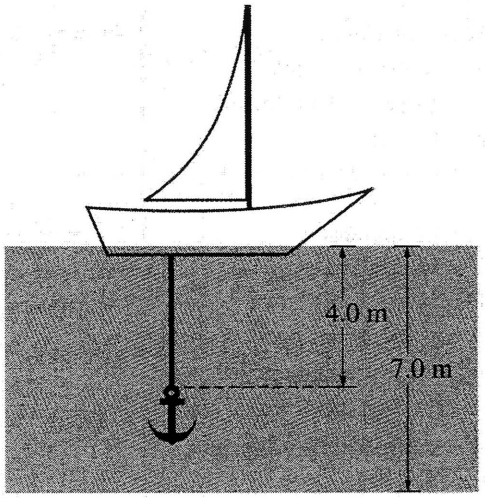


1. (10 points)

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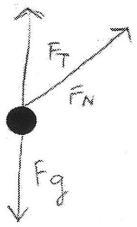
(a) On the dot below that represents the anchor, draw and label the forces (not components) that act on the anchor.



(b) Calculate the magnitude of the buoyant force acting on the anchor. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. DO NOT add anything to the figure in part (a).

$V = 6.25 \times 10^{-3} m^3$
$m = 50kg$
$\rho = 1000 kg/m^3$

$F_{buoy} = \rho V g$
$= (1000 kg/m^3)(6.25 \times 10^{-3} m^3)(9.8 m/s)$
$F_{buoy} = 61.25 kg$

(c) Calculate the tension in the rope. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. DO NOT add anything to the figure in part (a).

$m = 50kg$
$V = 6.25 \times 10^{-3} m^3$
$\rho = 1000 kg/m^3$

(d) The bottom of the boat is at a depth $d$ below the surface of the water. Suppose the anchor is lifted back into the boat so that the bottom of the boat is at a new depth $d'$ below the surface of the water. How does $d'$ compare to $d$ ?

✓ $d' < d$ ____ $d' = d$ ____ $d' > d$

Justify your answer.

It is less because the anchor was weighing it down causing it to be at a deeper depth

# AP® PHYSICS B
# 2013 SCORING COMMENTARY

## Question 1

### Overview

The intent of the question was to draw a free body diagram, use it to apply Newton's second law to the situation, and use the resulting equation it to solve for an unknown force. The question required students to calculate the weight of and buoyant force on an object, and to demonstrate a conceptual understanding of Archimedes' principle for a floating object and a submerged object.

**Sample: B1-A**
**Score: 9**

This is an excellent example of a well-organized response and almost earned full credit. In part (a) all three forces are drawn and labeled correctly. The arrows are all touching the dot and there are no extraneous forces. In part (b) the correct expression for the buoyant force $F_B = \rho Vg$ is used to obtain the correct answer with proper units. In part (c) the correct expression of Newton's second law at equilibrium is used and substituted the correct values for the buoyant and gravitational forces. In part (d) the correct answer, $d' > d$, is selected, but the justification is incorrect—the buoyant force would be greater, not less, and 1 point was lost.

**Sample: B1-B**
**Score: 5**

In part (a) 1 point was earned for correctly showing and labeling the tension force acting upward. The buoyant force is in the wrong direction, and there is no vector for the gravitational force. Full credit was earned in part (b). In part (c) 2 points were earned for substituting correct values for the buoyant force and calculation of the gravitational force. The third point was not earned because a correct expression of Newton's second law when the forces are at equilibrium is not given. No credit was earned in part (d) because the incorrect selection is made, which resulted in the justification not being considered.

**Sample: B1-C**
**Score: 2**

In part (a), 2 points were earned for correctly showing and labeling the tension upward and the gravitational force downward. An extraneous normal force vector is drawn, causing a 1 point deduction and resulting in part (a) earning a total of 1 point. One point was earned in part (b) for the use of the correct expression for the buoyant force, $F_B = \rho Vg$. However, full credit was not earned because the answer obtained does not have the correct units. Part (c) has no useful work and earned no credit. No credit was earned in part (d) because the incorrect selection is made.