AP® PHYSICS B
2010 SCORING GUIDELINES (Form B)

General Notes

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for the solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong — for example, a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth 1 point and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive an expression it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics Exams equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams and what is expected for each, see "The Free-Response Sections — Student Presentation" in the *AP Physics Course Description*.

4. The scoring guidelines typically show numerical results using the value $g = 9.8\ \text{m/s}^2$, but use of $10\ \text{m/s}^2$ is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

AP® PHYSICS B
2010 SCORING GUIDELINES (Form B)

Question 6

10 points total **Distribution of points**

(a) 2 points

For indicating that the buoyant force is the difference between the scale readings 1 point
$F_b = 17.8\text{ N} - 16.2\text{ N}$
For the correct answer with units 1 point
$F_b = 1.6\text{ N}$

(b) 3 points

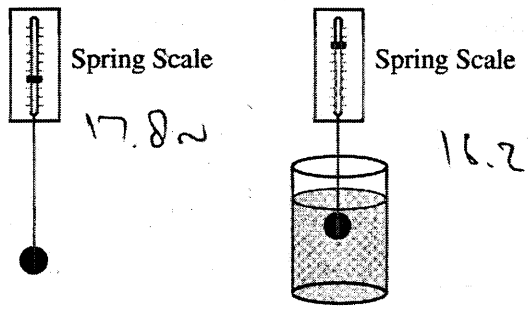
For indicating that the buoyant force equals the weight of the displaced water 1 point
$F_b = m_w g$
For indicating the correct relationship between mass and volume 1 point
$m = \rho V$
The volume of displaced water equals the volume of the object.
$F_b = \rho_w V_w g = \rho_w V_o g$
$V_o = F_b / \rho_w g$
For substituting the value of buoyant force from part (a) 1 point
$V_o = (1.6\text{ N}) / \left(1000\text{ kg/m}^3\right)\left(9.8\text{ m/s}^2\right)$
$V_o = 1.6 \times 10^{-4}\text{ m}^3$

(c) 2 points

For using the relationship between mass and density 1 point
$\rho_o = m_o / V_o$
$\rho_o = \dfrac{w_o / g}{V_o} = w_o / g V_o = (17.8\text{ N}) / \left(9.8\text{ m/s}^2\right)\left(1.6 \times 10^{-4}\text{ m}^3\right)$
For the correct answer 1 point
$\rho_o = 1.1 \times 10^4\text{ kg/m}^3$

(d) 3 points

For indicating that the pressure would decrease 1 point
For correctly indicating an intermediate effect: the height of the water will decrease or the total force at the bottom of the water is less. 1 point
For a correct relationship between the intermediate effect and the pressure: $P \propto \rho g h$ or $P = F/A$ 1 point



Object in Air Object in Water

6. (10 points)

An object is suspended from a spring scale first in air, then in water, as shown in the figure above. The spring scale reading in air is 17.8 N, and the spring scale reading when the object is completely submerged in water is 16.2 N. The density of water is 1000 kg/m^3 .

(a) Calculate the buoyant force on the object when it is in the water.

$F_{buoy} = 17.8 - 16.2$

$F_{buoy} = 1.6\ N$

(b) Calculate the volume of the object.

$F_{buoy} = \rho V g$

$1.6 = 1000\ V(9.81)$

$V = 1.631 \times 10^{-4}\ m^3$

(c) Calculate the density of the object.

$F = mg$

$17.8 = m\ 9.81$

$m = 1.8145\ kg$

$\rho = \frac{Mass}{V}$

$= \frac{1.8145}{1.631 \times 10^{-4}} \Rightarrow 11,126.9\ kg/m^3$

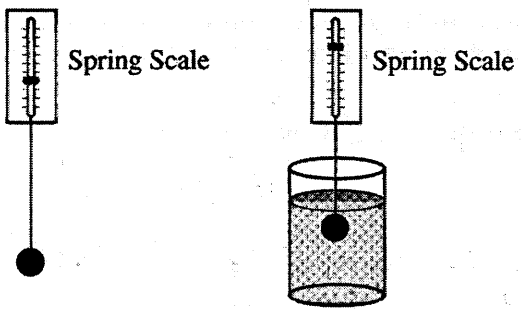
GO ON TO THE NEXT PAGE.

(d) How would the absolute pressure at the bottom of the water change if the object was removed? B-6A-2

___ It would increase. ✓ It would decrease ___ It would remain the same.

Justify your answer.

When the object is placed in the container, the weight pushing down onto the bottom of the container is added. There is more pressure at the bottom with the object. But when removed, the force by the object is removed so the absolute pressure would decrease.



Object in Air Object in Water

6. (10 points)

An object is suspended from a spring scale first in air, then in water, as shown in the figure above. The spring scale reading in air is 17.8 N, and the spring scale reading when the object is completely submerged in water is 16.2 N. The density of water is 1000 kg/m^3 .

(a) Calculate the buoyant force on the object when it is in the water.

$F_{bouy} = \rho V g$

$F_{bouy} = 17.8 - 16.2$

$= 1.6\ N$

$g = 9.8$

$F_{bouy} = 1000 * V * 9.8$

$F_{bouy} = 9800V$

(b) Calculate the volume of the object.

$F_{bouy} = \rho V g$

$V = \frac{F_{bouy}}{\rho g}$

$V = \frac{1.6}{1000 \times 9.8}$

$V = 1.6326 \times 10^{-4}\ m^3$

$V = 163.31\ cm^3$

(c) Calculate the density of the object.

$\rho = \frac{m}{V}$

$\rho = \frac{16.2 \div 9.8}{1.6326 \times 10^{-4}}$

$\rho = 10125.33\ kg/m^3$

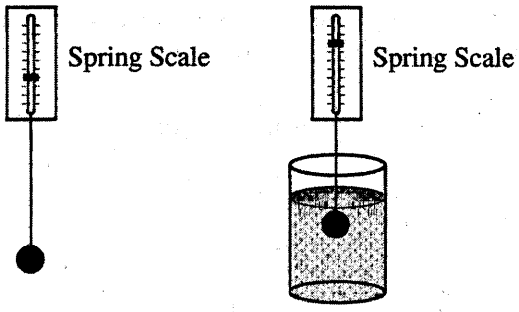
(d) How would the absolute pressure at the bottom of the water change if the object was removed?

___ It would increase. ___ It would decrease _X_ It would remain the same.

Justify your answer.

$P = P_0 + \rho g h$

P_0 is a constant if you are on Earth the same with g. The density of the liquid doesn't change when the object is removed and the ~~being~~ depth of the container does not change so the pressure remains constant.



Object in Air Object in Water

6. (10 points)

An object is suspended from a spring scale first in air, then in water, as shown in the figure above. The spring scale reading in air is 17.8 N, and the spring scale reading when the object is completely submerged in water is 16.2 N. The density of water is 1000 kg/m^3.

(a) Calculate the buoyant force on the object when it is in the water.

$F = \rho V g$ $\rho = 1000\ kg/m^3$

$F = 1000\ kg/m^3 \times V \times 9.8\ m/s^2$

(b) Calculate the volume of the object.

$V = \frac{4}{3}\pi r^3$

(c) Calculate the density of the object.

$\rho = \frac{m}{V}$

(d) How would the absolute pressure at the bottom of the water change if the object was removed?

___ It would increase. ✓ It would decrease ___ It would remain the same.

Justify your answer.

Because when we added the object inside the water the water will produce more pressure on the container

AP® PHYSICS B
2010 SCORING COMMENTARY (Form B)

Question 6

Sample: B-6A
Score: 10

Full credit was earned in all parts. Note that in part (d) the fact that pressure varies directly with force is expressed verbally, rather than mathematically; this was considered sufficient to earn the final point.

Sample: B-6B
Score: 6

Full credit was earned in parts (a) and (b). Part (c) earned 1 point for using the correct relationship for density, but the incorrect force is used in the calculation so the answer point was not earned. Part (d) has the wrong choice and incorrect reasoning, missing the fact that the depth of the water does change, so no credit was earned.

Sample: B-6C
Score: 2

No meaningful work is shown in parts (a) and (b). Part (c) earned 1 point for identifying the correct equation. Part (d) earned 1 point for the correct choice, but no credit for a justification that fails to mention changing depth or the relationship between depth and pressure.