2025

AP® Physics 1: Algebra-Based

Sample Student Responses and Scoring Commentary

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Free-Response Question 4

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Question 4: Qualitative Quantitative Translation (QQT) — 8 points

A	For indicating $a_1 < a_2$	**Point A1**
	For a justification that indicates that the blocks have the same weight or mass	**Point A2**
	For a justification that indicates that the salt water exerts a larger buoyant force than the freshwater exerts (or the freshwater exerts a smaller buoyant force than the saltwater exerts)	**Point A3**
	Example Response *There are identical downward forces (mg) on the block in both liquids. Each submerged block also has an upward buoyant force. Because the buoyant force is proportional to the density of the fluid, the block in salt water has a larger buoyant force exerted on it. Therefore, the block in salt water has a larger net force and so has a larger acceleration.*	
B	For a multistep derivation that includes Newton's second law	**Point B1**
	For indicating ρVg is the buoyant force	**Point B2**
	For a correct expression for the initial upward acceleration a, consistent with the indicated expression for buoyant force **Scoring Note:** A correct, isolated, final expression for a earns points B2 and B3.	**Point B3**
	Example Response $\Sigma F = m_{\text{sys}} a_{\text{sys}}$ $F_B - mg = ma$ $\rho Vg - mg = ma$ $a = \frac{\rho Vg}{m} - g$	
C	For attempting to address the functional dependence between a and ρ in the equation derived in part B **Scoring Note:** It is not necessary to use the functional dependence correctly to earn this point. The response only needs to use functional dependence language such as proportional, inversely proportional, related, numerator, and denominator, to relate a and ρ.	**Point C1**
	For correctly using functional dependence to evaluate the relationship between a and ρ consistent with the expression derived in part B and the claim made in part A	**Point C2**
	Example Response *The expression for the acceleration a is consistent with part A. In part A, I said the acceleration would be larger in salt water because the density is greater. In my expression, the acceleration increases with increasing density because of the* $\frac{\rho Vg}{m}$ *term.*	

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 4

PART A

$a_2 > a_1$

In both scenarios, the block feels a downward F_g and an upward F_b. Both blocks have the same mass, so both F_g are equal. However, since the liquid is more dense in scenario 2, and since the blocks in both scenarios have the same volume, the buoyant force in scenario 2 is greater than F_{b1}. ($F_b = \rho_f V_o g$)

Therefore, with a greater net upward force in scenario 2, the acceleration in scenario 2 will be greater than a_1.

PART B

$\Sigma F = ma$

$\Sigma F = F_b - F_g = \rho_L V_o g - mg = ma$

$$a = \frac{\rho V g - mg}{m}$$

PART C

consistent.

V, g, and m are constant across both scenarios. In my derivation, ρ_L is positive in the numerator. Thus, the larger the value of ρ is, the larger the value of a. $\rho_2 > \rho_1$, and so it makes sense that $a_2 > a_1$.

(ρ and a are directly related)

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Question 4

PART A

$a_1 < a_2$

Since the force acting on the block is directly proportional to the density, as density increases, force increases. Also, since force and acceleration and directly proportional, as the force increases, so does acceleration.

PART B

$F = ma$ $\quad F = pVg$

$a = \frac{F}{m}$

$a = \frac{pVg}{m}$

PART C

~~[illegible]~~ the expression $a = \frac{pVg}{m}$ is consistent with $a_1 < a_2$. This is because acceleration is directly proportional to density. Therefore, as the density increases in scenario 2, the acceleration will also increase.

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Question 4

PART A $a_1 > a_2$

The acceleration of the block is greater in the freshwater, because while the buoyant force is the same for the blocks, the upward force on the block is therefore the same in both scenarios. But since the salt water is more dense than the freshwater, the block has a larger force pushing down on it in the salt water than the freshwater, meaning it accelerate slower in the saltwater than in the freshwater.

PART B $K_g = R_b$

$a = F_b + P$

$a = \rho V g + P$

PART C

yes because in this equation if the liquid has a greater density, it will have a smaller acceleration.

Question 4

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

NEW for 2025: The question overviews can be found in the *Chief Reader Report on Student Responses* on AP Central.

Sample: 4A
Score: 8

Part A earned all three points. The first point (A1) was earned because the response correctly indicates that a_1 is less than a_2. The second point (A2) was earned because the response correctly states that the force of gravity is the same in both cases. The third point (A3) was earned because the response indicates that the buoyant force is greater in Scenario 2.

Part B earned all three points. The first point (B1) was earned because the response presents a multistep derivation that uses Newton's second law. The second point (B2) was earned because the response identifies the buoyant force as ρVg. The third point (B3) was earned because the response indicates a correct expression for the object's initial upward acceleration.

Part C earned both points. The first point (C1) was earned because the response demonstrates an attempt to address the functional dependence between acceleration and density using the equation derived in part B. The second point (C2) was earned because the response correctly connects the functional dependence on density from the expression in part B to the acceleration comparison described in part A.

Sample: 4B
Score: 5

Part A earned one out of three points. The first point (A1) was earned because the response correctly indicates that a_1 is less than a_2. The second point (A2) was not earned because the response does not state that the force of gravity is the same in both scenarios, which is necessary to compare the net forces. The third point (A3) was not earned because the response does not clearly identify the buoyant force as increasing in Scenario 2.

Part B earned two out of three points. The first point (B1) was earned because the response presents a multistep derivation using Newton's second law. The second point (B2) was earned because the response states that the buoyant force is equal to ρVg. However, the third point (B3) was not earned because the expression for the initial upward acceleration is incorrect. The response mistakenly assumes that the buoyant force is the only force acting on the block and fails to account for the gravitational force.

Part C earned both points. The first point (C1) was earned because the response includes an attempt to address the functional dependence between acceleration and density based on the equation derived in part B. The second point (C2) was earned because the response correctly applies this functional dependence to explain the relationship between the expression from part B and the acceleration comparison made in part A.

Question 4 (continued)

Sample: 4C
Score: 2

Part A did not earn any of the three points. The first point (A1) was not earned because the response incorrectly states that a_1 is greater than a_2. The second point (A2) was not earned because the response does not state that the force of gravity is the same in both scenarios, which is necessary to compare the net forces. The third point (A3) was not earned because the response incorrectly asserts that the buoyant force is the same in both scenarios, rather than recognizing that it is greater in Scenario 2.

Part B earned one out of three points. The first point (B1) was not earned because the response does not use Newton's second law. The second point (B2) was earned because the response correctly uses substitution to indicate that the buoyant force is equal to ρVg. The third point (B3) was not earned because the response does not provide a correct expression for the initial upward acceleration.

Part C earned one out of two points. The first point (C1) was earned because the response includes an attempt to address the functional dependence between acceleration and density based on the equation derived in part B. However, the second point (C2) was not earned because the response incorrectly claims that a greater density leads to a smaller acceleration, which is inconsistent with the expression derived in part B.