

ANSWERS - AP Physics Multiple Choice Practice – Fluids

Solution	Answer
1. FBD has F_t pointing down F_b pointing up and weight (mg) down. $F_{net} = 0$ $F_b - F_t - mg = 0$ The buoyant force is given by the weight of the displaced water. Since the water displaced volume is equal to the corks displaced volume and the water weight for the same volume would be 4 times heavier (based on the given cork weight = 25% water weight) compared to the cork, the buoyant force is equal to 4 x the cork weight = $4mg$. Using the force equation created initially. $F_t = F_b - mg = 4mg - mg = 3mg$	D
2. Definition of Pascal's principle	A
3. A 1 m^3 volume cube under water displaces 1 m^3 of water. This weight of water = $pVg = 1000(1)(10) = 10000 \text{ N}$ which is equivalent to the buoyant force. The apparent weight in water is $m_{app}g = 18300(10) = 183000 \text{ N}$. This apparent weight is lessened by the buoyant force pulling up with 10000 N of force. So outside of the water, this upwards force would not exist and the actual weight would be 193000 N which equal 19300 kg of mass.	D
4. Using fluid continuity. $A_1v_1 = A_2v_2$ $\pi R^2v_1 = \pi(2R)^2v_2$ $v_1 = 4v_2$	E
5. This is based on two principles. 1 – Bernoulli's principle says that when speed increases pressure drops. Second, continuity says more area means less speed based on $A_1v_1 = A_2v_2$. So the smallest area would have the largest speed and therefore most pressure drop.	B
6. Since A and B have the same mass and density, they have the same volume. C has the same volume as A and B since it's the same shape as B. So all three objects have the same volume. When submerged, they will all displace the same amount of water and therefore all have the same buoyant force acting on them. <i>Note: if the objects were floating instead of submerged then the heavier ones would have larger buoyant forces.</i>	E
7. Pascals principle of equal pressure transfer in a fluid allows for hydraulic lifts to function.	A
8. Pascals principle says $P_1 = P_2$ $F_1/A_1 = F_2/A_2$ $F_2 = F_1A_2 / A_1 = 500(40)/(2)$	C
9. Buoyant force is equal to weight of displaced fluid. Since the density is constant and the volume displaced is always the same, the buoyant force stays constant	B
10. The wood is floating and is only partially submerged. It does not displace a weight of water related to its entire volume. The iron however is totally submerged and does displace a weight of water equal to its entire volume. Since the iron displaces more water, it has a larger buoyant force acting on it.	B
11. For floating objects, the weight of the displaced fluid equals the weight of the object. For a more dense fluid, less of that fluid needs to be displaced to create a fluid weight equal to the weight of the object. Since the salt water is more dense, it will not need as much displaced.	B
12. Definition of specific gravity. $s.g = \rho_x / \rho_{H2O}$	A
13. Same as question #5, but moving to more area \rightarrow less speed \rightarrow more pressure	B
14. Flow continuity. $A_1v_1 = A_2v_2$ $\pi(0.02)^2(1) = \pi(0.01)^2v_2$	D
15. Buoyant force is based on how much weight of water is displaced. Since all three are completely submerged they all displace the same amount of water so have equal buoyant forces.	C

16. For floating objects, the buoyant force equals the weight of the objects. Since each object has the same weight, they must have the same buoyant force to counteract that weight and make them float. *IF the equal mass objects sunk, then the one with the smaller density would have a larger volume and displace more water so have a larger buoyant force. But that is not the case here.* D
17. $P = F / A$ $1 \times 10^5 = F / (22 \times 5)$ E
18. $P = F / A$ $= ma / A$ $= kg (m/s^2) / m^2$ $= kg / (m \cdot s^2)$ D
19. Three forces act on the block, F_t down, mg down and F_b up. $F_{net} = 0$ $F_b - F_t - mg = 0$ D
 $F_b - 3 - 5 = 0$ $F_b = 8 \text{ N} - \text{weight of displaced water} = \rho_{h20} V_{disp} g$
 $8 = (1000) V (10) \rightarrow V = 0.0008 \text{ m}^3$
20. For floating objects $mg = F_b$ $\rho_{obj} V_{obj} g = \rho_{h20} V_{disp} g$ E
 $\rho_{obj} (V)g = 1000 (0.6V) g$ $\rho_{obj} = 600$
 In oil the same is true $\rho_{obj} V_{obj} g = \rho_{oil} V_{disp} g$ $(600)Vg = (800) x\%V g$ $x\% = 0.75$
21. Same as question 4 A
22. Based on continuity, less area means more speed and based on Bernoulli, more speed means less pressure. B
23. The weight of the mass is 4N. The scale reading apparent weight is 3N so there must be a 1N buoyant force acting to produce this result. B
24. Since the pressure in a fluid is only dependent on the depth, they all have the same fluid pressure at the base. Since all of the bases have the same area and the same liquid pressure there, the force of the liquid given by $P=F/A$ would be the same for all containers. *Note: IF instead this question asked for the pressure of the container on the floor below it, the container with more total mass in it would create a greater pressure, but that is not the case here.* E
25. As the fluid flows into the smaller area constriction, its speed increases and therefore the pressure drops. Since the pressure in the constriction is less than that outside at the water surface, fluid is forced up into the lower tube. A
26. The buoyant force would be the difference between the two scale readings ... $(.09\text{kg})(10 \text{ m/s}^2) = 0.9 \text{ N}$ of buoyant force. This equals the weight of displaced water. $F_b = \rho_{h20} V_{disp} g$ E
 $0.9 = 1000 (V) (10) \dots$ gives the volume of the displaced water = 0.00009 which is the same as the volume of the object since its fully submerged.
 Now using $\rho = m/V$ for the object we have ... $\frac{0.45}{0.00009} = \frac{45}{100} * \frac{10000}{9} = 5000$
27. Use flow continuity. $A_1 v_1 = A_2 v_2$ C
 since the area is the same at both locations the speed would also have to be the same.
28. Apply Bernoulli's equation. $P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$ D
 $(9.5)(100000) + 0 + \frac{1}{2} (1000)(10)^2 = P_2 + (1000)(10)(15) + \frac{1}{2} (1000)(10)^2$
 $P_2 = 800000 \text{ N/m}^2$

29. Both objects are more dense than water and will sink in the pool. Since both have the same volume, they will displace the same amount of water and will have the same buoyant forces. C
30. Again both samples sink. Also, both samples have the same mass but different densities. For the same mass, a smaller density must have a larger volume, and the larger volume displaces more water making a larger buoyant force. So the smaller density with the larger volume has a larger buoyant force. B
31. V of this ball is $\frac{4}{3} \pi r^3 = \frac{4}{3} \pi (0.4)^3 = 0.2681 \text{ m}^3$. For the ball to just sink, it is on the verge of floating, meaning the weight of the ball equals the buoyant force of the fully submerged ball.
 $mg = \rho_{\text{fl}} V_{\text{disp}} g$ $m(10) = 1400(0.2681)(10)$ $m = 375 \text{ kg}$ B
32. This object will float, so $m_{\text{obj}} g = F_b$ $\rho_{\text{obj}} V_{\text{obj}} g = \rho_{\text{ocean}} V_{\text{disp}} g$
 $(0.95 \times 10^3)(V)(10) = (1.1 \times 10^3)(x\% V)(10)$
 Gives $x\% = 0.86$ but that is the amount submerged, so the visible amount would be $1 - 0.86$ A
33. Statement associated with Bernoulli's principle E
34. $s.g = \rho_{\text{obj}} / \rho_{\text{H}_2\text{O}}$ $0.82 = \rho_{\text{obj}} / 1000$ $\rho_{\text{obj}} = 820 \dots$ then $\rho = m/V$ $820 = m / 1.3$ D
35. The apparent weight is the air weight – the upwards buoyant force. The buoyant force is given by $F_b = \rho_{\text{fl}} V_{\text{disp}} g = 1.25 \times 10^3 (0.375)(10) = 4687.5 \text{ N}$.
 The apparent weight is then $(600)(10) - 4687.5 = 1312.5 \text{ N}$ D
36. Using fluid continuity. $A_1 v_1 = A_2 v_2$ $\pi(7R)^2 v_1 = \pi(R)^2 v_2$ $v_1 = v_2 / 49$ A
37. The fluid flow is occurring in a situation similar to the diagram for question #27. Apply Bernoulli's equation. $P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$
 $P + 0 + \frac{1}{2} \rho v^2 = P_2 + \rho g y + \frac{1}{2} \rho (2v)^2$
 $P_2 = P + \frac{1}{2} \rho v^2 - \frac{1}{2} 4 \rho v^2 - \rho g y$ $= P - \frac{3}{2} \rho v^2 - \rho g y$ B
38. s.g is density / density and has no units E
39. Definition of Archimedes principle D
40. $P_{\text{abs}} = P_g + P_o = 2.026 \times 10^5 + 1.01 \times 10^5 = 3.03 \times 10^5 \text{ Pa}$ D
41. Definition of buoyant force C
42. Using fluid continuity with W as river width. $A_1 v_1 = A_2 v_2$ $4(W)(12) = (8)(W)v_2$ $v_2 = 6 \text{ m/s}$ C
43. The relevant formula here is $P = P_o + \rho g h$ B
 Answer (a) is wrong, because at y_1 on both arms, the pressure is just the atmospheric pressure. The pressure in the right arm at y_3 is still just atmospheric, but on the left, it is atmospheric plus $\rho g(y_1 - y_3)$. That rules out (a). The pressure at the bottom of the tube is everywhere the same (Pascal's principle), which rules out (c), and at the same time, tells us (b) is right. At y_2 , we can say $P = P_{\text{bottom}} - \rho_{\text{Hg}} g y_2$ on both sides, so the pressure is equal. Answer (d) is wrong because at y_3 , the right arm is supporting only the atmosphere, while the left arm is supporting the atmosphere plus $\rho_{\text{H}_2\text{O}} g h$. Finally, (e) is silly because both arms at height y_1 are at atmospheric pressure.
44. Apply Bernoulli's equation. $P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$ A
 $P_1 = P_2 + \rho g(y_2 - y_1)$

45. $P = F / A = 30 / \pi r^2 \dots$ use 3 for π since its an estimate ... $30 / (3*(.01)^2) = 100000 \text{ Pa}$ E
46. From a force standpoint, for the object to be completely submerged there would be three forces acting. F_b up, mg down and F_{push} down. $F_b = F_{\text{push}} + mg$ $F_{\text{push}} = F_b - mg$ D
 $F_{\text{push}} = \rho_{\text{h2o}} V_{\text{disp}} g - mg$
 $= (1000)(2.5 \times 10^{-2})(10) - (5)(10) = 200 \text{ N}$
47. Using fluid continuity. $A_1 v_1 = A_2 v_2$ $\pi(D/2)^2 v_1 = \pi(d/2)^2 v_2$ solve for v_2 E

2002B6.

a) Example 1: Measure the unstretched length of the spring. Hang it with the object at rest and measure the stretched length. Call the difference in these lengths Δx . Equating the weight of the object and the force exerted by the extended spring gives $mg = k\Delta x$ from which k can be determined.

Example 2: Set the hanging mass into oscillation. Determine the period T by timing n oscillations and dividing that time by n . The equation $T = 2\pi\sqrt{m/k}$ can then be used to find k .

b) The spring is stretched less when the object is at rest in the fluid. The fluid exerts an upward buoyant force on the object. Since the net force on the object is still zero, the spring does not need to exert as much force as before and thus stretches less.

c&d)

- 1) Measure the length of the spring when the object is immersed in the liquid, and subtract the unstretched length to determine the amount the spring is stretched. This will allow calculation of the force exerted by the spring on the object.
- 2) The volume of fluid displaced is equal to the volume of the object, which can be determined from the given mass and density of the object.
- 3) The buoyant force on the object is equal to the difference of the object's weight and the force exerted by the spring.
- 4) The buoyant force also equals the weight of the displaced fluid, which equals the product of the fluid density, displaced volume, and g .

<u>Symbol</u>	<u>Quantity</u>
ρ	fluid density
V	object volume = displaced water volume
g	acceleration of gravity
m	mass of object
x	spring stretch in air
x_w	spring stretch in water

First solving for k in air. $mg = kx$

Then in the fluid. $F_{sp} = kx_w$

$$F_{net} = 0 \quad F_b = mg - F_{sp} \quad \rho Vg = mg - kx_w \quad \rho Vg = mg - (mg/x)x_w \quad \text{solve for } \rho$$

B2003B6.

- a) i) The total mass of water moved can be found with the density and volume $m = \rho V = (1000)(0.35) = 350 \text{ kg}$ of water. This water is moved a distance 85 m so the work done to move it is $W = Fd = (350)(9.8)(85) = 291,500 \text{ J}$.

ii) The force needed to move the water = the weight of the water (mg).

Using, $P = Fd/t = (350)(9.8)(85) / (2\text{hrs} * 3600 \text{ s/hr}) = 40.5 \text{ W}$

- b) i) Using fluid continuity. $A_1 v_1 = A_2 v_2$ $\pi(.03/2)^2(0.5) = \pi(0.0125/2)^2 v_2$ $v_2 = 2.88 \text{ m/s}$

ii) Apply Bernoulli's equation. $P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$
 $y_1 = 0$ $P_2 = \text{atmospheric (open faucet)}$

$$P_1 + 0 + \frac{1}{2} (1000) (0.5)^2 = 1.01 \times 10^5 + (1000)(9.8)(85) + \frac{1}{2} (1000)(2.88)^2 \quad P_1 = 938000 \text{ Pa}$$

2003B6.

a) $P = \rho g h = (1025)(9.8)(35) = 351,600 \text{ Pa}$

b) $P_{\text{abs}} = P_o + \rho g h = 1.01 \times 10^5 + 343,000 = 452,600 \text{ Pa}$

- c) The FBD has three forces acting on it. The upwards lifting force, the upwards buoyant force and the downwards weight, mg. Constant velocity $\rightarrow F_{\text{net}} = 0$

$$F_t + F_b - mg = 0 \quad F_t = mg - F_b \quad F_t = (\rho_{\text{obj}} V_{\text{obj}})g - (\rho_{\text{h2o}} V_{\text{disp}})g \quad V_{\text{disp}} = V_{\text{obj}} \text{ call it } V$$

$$\rightarrow F_t = Vg (\rho_{\text{al}} - \rho_{\text{h2o}}) = (1 \times 10^{-3} \text{ m}^3)(9.8)(2700 - 1025) = 985 \text{ N}$$

- d) $F_t + F_b - mg = ma$ $F_t = mg - F_b + ma$ Comparing this tension equation to the one in part c you see that
the tension will increase since the quantity "ma" is being added here
-

2004B2.

$$a) P_{\text{abs}} = P_o + P_{\text{gauge}} \quad 413 \text{ atm} = 1 \text{ atm} + P_{\text{gauge}} \quad P_{\text{gauge}} = 412 \text{ atm}$$

$$b) P_{\text{gauge}} = \rho gh \quad 412(1.01 \times 10^5) = 1024(9.8)(h) \quad h = 4140 \text{ m}$$

- c) The fluid pressures acting are the outside water pressure (which includes the atmosphere at the surface acting down on it) and, the inside air pressure which is atmospheric. Since the atmospheric pressure acts both inside and is also included in the water pressure, the net force due to fluid pressure can be found by using the water's gauge pressure since the air pressures effectively cancel each other out.

$$P_{\text{gauge}} = F/A \quad 412(1.01 \times 10^5) = F/0.01 \quad F = 416,000 \text{ N}$$

- d) The force from c is not the true net force. The actual net force is zero as the window is at rest. This force from c is due to fluid pressures and is resisted by normal forces acting on the edges of the window where it is connected to the submarine.

$$e) v_f = v_i + at \quad 10 = 0 + a(30) \quad a = 0.33 \text{ m/s}^2$$

$$f) d = v_i t + \frac{1}{2} at^2 \quad d = 0 + \frac{1}{2}(0.33)(30)^2 \quad d = 150 \text{ m}$$

- g) The total depth is 4140 m. There are two parts to the trip, the first 150 m covered while accelerating and the second (3990m) covered while moving at constant speed. The parts must be calculated separately. Part one, during acceleration, was already given as taking 30 second. The second part at a constant speed can simply be found using $\bar{v} = d/t$, $10 = 3990/t$, $t_2 = 399$ seconds. So the total time of travel was 429 seconds.

B2004B2.

- a) The descent occurs at two different accelerations and must be analyzed in the two sections.

Section 1 starts from rest and accelerates, find the time in that part

$$v_{1f} = v_{1i} + a_1 t_1 \quad 2 = 0 + 0.10 t_1 \quad t_1 = 20 \text{ seconds.}$$

$$d_1 = v_{1i} t + \frac{1}{2} a_1 t_1^2 \quad d_1 = \frac{1}{2}(0.10)(20)^2 \quad d_1 = 20 \text{ m}$$

Section 2 occurs at a constant speed equal to the final speed in section 1 and will occur over the remaining distance $d_2 = 60\text{m}$.

$$\bar{v}_2 = d_2 / t_2 \quad 2 = 60 / t_2 \quad t_2 = 30 \text{ seconds} \quad t_{\text{total}} = t_1 + t_2 = 50 \text{ seconds}$$

- b) Weight of water above the bell is a cylindrical column with a height of $h=80$ m and area of $A=9 \text{ m}^2$. This gives us the volume of the water above the bell given by $V = Ah = 720 \text{ m}^3$.

$$\text{The weight of this column} = m_{h20} g = (\rho_{h20} V) g = (1025)(720)(9.8) = 7.2 \times 10^5 \text{ N}$$

$$c) P_{\text{abs}} = P_o + \rho gh = 1.01 \times 10^5 + (1025)(9.8)(80) = 9 \times 10^5 \text{ Pa}$$

- d) Since there is air pressure inside the bell, and the absolute pressure on the outside also includes the air pressure, these two pressures essentially cancel each other out and we only need to push against the water pressure alone so we should use the gauge pressure to find the needed force.

$$P_{\text{abs}} = P_o + P_{\text{gauge}} \quad 9 \times 10^5 = 1.01 \times 10^5 + P_{\text{gauge}} \quad P_{\text{gauge}} = 8 \times 10^5 \text{ Pa.}$$

$$F = PA = (8 \times 10^5)(\pi(0.25)^2) = 1.58 \times 10^5 \text{ N}$$

- e) To reduce the pushing force needed, you could increase the pressure inside the bell to create a smaller pressure difference between inside and outside. Or, by making the area of the hatch smaller the pushing force would be less. Or, you could use a lever inside that uses torque to provide mechanical advantage to amplify an applied force to one side of the lever. This would make the force pushing the hatch open the same but the required pushing force of a person less.

2005B5.

- a) We are given the volume of the raft and the surface area as well. Use this to first find the total height of the raft h_t
 $V = Ah_t \quad 1.8 = 8.2 h_t \quad h_t = 0.22 \text{ m}$

Since the raft is floating, the weight of the raft must equal the weight of the displaced fluid. We will define " h_s " as being the portion of the height of the raft below the water so that the displaced volume is given by $V = Ah_s$

$$m_{\text{raft}}g = \rho_{\text{h20}} V_{\text{disp}} g \quad \rho_{\text{raft}} V_{\text{raft}} g = \rho_{\text{h20}} V_{\text{disp}} g \quad \rho_{\text{raft}} V_{\text{raft}} = \rho_{\text{h20}} (Ah_s) \quad (650)(1.8) = (1000)(8.2)h_s \quad h_s = 0.143 \text{ m}$$

$$h = h_t - h_s = 0.22 - 0.143 = 0.077 \text{ m (the visible portion of the raft)}$$

- b) F_B equals weight of displaced water $= \rho_{\text{h20}} V_{\text{disp}} g = \rho_{\text{h20}} (Ah_s) g = (1000)(8.2)(0.143)(9.8) = 11500 \text{ N directed } \uparrow$

- c) Determine the extra buoyant force that will come from submerging the exposed raft volume $V_{\text{exp}} = Ah$

$$F_{\text{b(extra)}} = \rho_{\text{h20}} V_{\text{disp}} g = \rho_{\text{h20}} (Ah) g = (1000)(8.2)(0.077)(9.8) = 6187.7 \text{ N}$$

$$1 \text{ persons weight} = mg = 735 \text{ N. Total weight allowed / person weight} = 6187.7 / 735 = 8.41$$

So, an extra 8 people could come on without submerging the raft. You could also chop some arms or legs off and throw them on there also until you get up to the extra 0.41 of a person limit.

B2005B5.

- a) The force on the plug from the water inherently includes the atmosphere above it, so we use the absolute pressure.

$$P_{\text{abs}} = P_o + \rho gh = 1.01 \times 10^5 + (1025)(9.8)(20\text{m}) = 3 \times 10^5 \text{ Pa}$$

$$\text{The force is then found with } P = F/A \quad 3 \times 10^5 = F / (4 \times 10^{-5}) \rightarrow F = 12 \text{ N}$$

Note: This calculation of pressure (ρgh) only works since the fluid is at rest (static). For moving fluids, only Bernoulli's equation (or F/A in rare cases) can be applied for determining pressures.

- b) Though many of you may know the Torricelli theorem shortcut to this problem, when the AP exam graded this question, simply stating that equation and plugging in lost points. To be safe you should always start with Bernoulli's equation in its full form, cancel out terms that don't exist or are assumed zero, and solve from there.

$$P_1 + \rho gy_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho gy_2 + \frac{1}{2} \rho v_2^2$$

P_1 and P_2 are both open to atmosphere so are at P_o and cancel. Tank is large so v_1 is assumed small enough to be 0, y_2 is set as zero height.

$$\rho gy_1 = \frac{1}{2} \rho v_2^2 \quad v_2 = \sqrt{2gy_1} \text{ (as expected from Torricelli)} \dots v_2 = \sqrt{2(9.8)(20)} = 19.8 \text{ m/s}$$

- c) Volume flow rate $= Q = Av = (4 \times 10^{-5})(19.8) = 7.92 \times 10^{-4} \text{ m}^3/\text{s}$

2007B4.

- a) Volume flow rate $= Q = V/t = 7.2 \times 10^{-4} / (2\text{min} * 60 \text{ sec/min}) = 6 \times 10^{-6} \text{ m}^3/\text{s}$

- b) Your first thought is probably Bernoulli, but there are too many unknowns so this does not work. We can use the volume flow rate above to find the velocity.

$$Q = Av \quad 6 \times 10^{-6} = (2.5 \times 10^{-6}) v \quad v = 2.4 \text{ m/s}$$

- c) Use Bernoulli, same derivation as in the problem above (B2005B5) ... $v_2 = \sqrt{2gh} \quad (2.4) = \sqrt{2(9.8)h} \quad h = 0.29 \text{ m}$

- d) Left of beaker. Based on the formula derived above, the exit velocity is dependent on the height and with less horizontal exit velocity the range will be less ($d_x = v_x t$). This makes sense because less height would result in less pressure and decrease the speed the fluid is ejected at, thus lessening the range.

B2007B4.

a) Use Bernoulli, same derivation as problem B2005B5 ... $v_2 = \sqrt{2gh}$... $v_2 = \sqrt{2(9.8)(0.7)} \dots v_2 = 3.7 \text{ m/s}$

b) Volume flow rate $Q = Av = \pi(0.001)^2(3.7) = 1.16 \times 10^{-5} \text{ m}^3/\text{s}$

c) $Q = V/t$ $1.16 \times 10^{-5} = V / (2 \text{ min} * 60 \text{ s/min})$ $V = 0.0014 \text{ m}^3$

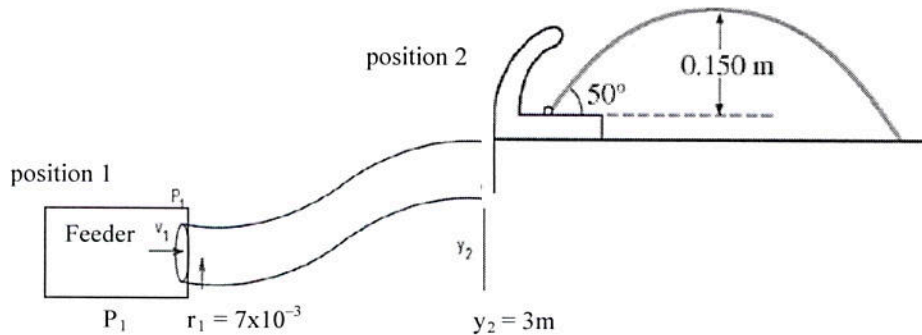
d) Free fall. $d = v_i t + \frac{1}{2} g t^2$ $-0.25 = (-3.7 t) + \frac{1}{2}(-9.8) t^2$ solve quadratic $t = 0.062 \text{ s}$
 Alternatively, first determine v_f at the 0.25 m location then use $v_f = v_i + at$ to solve for t .

2008B4.

a) Using projectile methods. $v_{fy}^2 = v_{iy}^2 + 2ad_y$ $0 = (v_i \sin 50^\circ)^2 + 2(-9.8)(0.15)$ $v_i = 2.24 \text{ m/s}$

b) Volume flow rate $= Q = Av = \pi(4 \times 10^{-3})^2 (2.24) = 1.13 \times 10^{-4} \text{ m}^3/\text{s}$

c) If you don't understand the wording, here is what the problem is saying



First we need to find the velocity of the water at the feeder using continuity
 $A_1 v_1 = Q_2$ $\pi(7 \times 10^{-3})^2 (v_1) = 1.13 \times 10^{-4}$ $v_1 = 0.73 \text{ m/s}$

Bernoulli. Position 2 is the fountain spigot which is open so at atmospheric pressure. $y_1 = 0$ no height.

$$P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$$

$$P_1 + 0 + \frac{1}{2} (1000)(0.73)^2 = (1.01 \times 10^5) + (1000)(9.8)(3\text{m}) + \frac{1}{2} (1000)(2.24)^2$$

$$P_1 = 1.32 \times 10^5 \text{ Pa which is the absolute pressure of the feeder.}$$

To find the gauge pressure of the feeder. $P_{\text{abs}} = P_{\text{gauge}} + P_o$ $1.32 \times 10^5 = P_{\text{gauge}} + 1.01 \times 10^5$

$$P_{\text{gauge}} = 31600 \text{ Pa.}$$

Note: This gauge pressure could be determined directly in Bernoulli's equation by realizing that P_1 includes atmospheric pressure as part of its total value and that P_2 was equal to atmospheric pressure, so by elimination of the term P_2 , P_1 becomes the gauge pressure. This should be stated in the solution if it is the chosen solution method.

B2008B4

a) Volume flow rate = $Q = Av = \pi(0.015)^2 (6) = 0.0042 \text{ m}^3/\text{s}$

b) First we need to find the velocity of the water in the pipe below using continuity

$$A_1 v_1 = Q_2 \quad \pi(0.025)^2 (v_1) = 0.0042 \quad v_1 = 2.16 \text{ m/s}$$

Bernoulli. Position 2 is the fountain spigot which is open so at atmospheric pressure. $y_1 = 0$ no height.

$$P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$$

$$P_1 + 0 + \frac{1}{2} (1000)(2.16)^2 = (1.01 \times 10^5) + (1000)(9.8)(2.5\text{m}) + \frac{1}{2} (1000)(6)^2 \quad P_1 = 141000 \text{ Pa}$$

c) Determine the launch speed needed to reach 4m.

Free fall of a water droplet. $v_f^2 = v_i^2 + 2gd \quad (0) = v_i^2 + 2(-9.8)(4) \quad v_i = 8.85 \text{ m/s}$

Use flow rate to find new area needed. $Q = Av \quad (0.0042) = A (8.85) \quad A_{\text{new}} = 4.75 \times 10^{-4} \text{ m}^2$

Find new radius $A_{\text{new}} = \pi r_{\text{new}}^2 \quad 4.75 \times 10^{-4} \text{ m}^2 = \pi r_{\text{new}}^2 \quad r_{\text{new}} = 0.0122 \text{ m}$

2009B5.

a) There are three forces acting on the masses in each case. Tension up, buoyant force up, weight down. Since they are at rest we have. $F_{\text{net}} = 0 \quad F_t + F_b = mg \quad F_t = mg - F_b$ so the largest F_b makes the largest F_t

We are to assume the diagram is to scale and that clearly the volumes of the three containers are different. The one with the largest volume displaces the largest amount and weight of water and will have the largest buoyant force acting on it. So since they all displace different volumes (and weights) of water they all have different buoyant forces, and based on the equation shown above will have different tensions.

b) The mass of the object is given by $m = \rho_{\text{obj}} V_{\text{obj}}$.

Using the equation from part a,

$$F_t + F_b = mg, \quad F_t + F_b = (\rho_{\text{obj}} V_{\text{obj}}) g \quad (0.0098) + F_b = (1300)(1 \times 10^{-5})(9.8) \quad F_b = 0.1176 \text{ N}$$

c) The buoyant force is by definition equal to the weight of the displaced fluid.

$$F_b = (\rho_{\text{fluid}} V_{\text{disp}}) g \quad 0.1176 = \rho_{\text{fluid}} (1 \times 10^{-5})(9.8) \quad \rho_{\text{fluid}} = 1200 \text{ kg/m}^3$$

d) With only half of the volume submerged, $\frac{1}{2}$ as much water will be displaced and the buoyant force will be half the size. Based on the formula from part A, less buoyant force will make a larger tension. This also makes sense conceptually. Objects have large apparent weights in air than water so having some of it in the air will increase its apparent weight.

B2009B3.

- a) Using fluid continuity. $A_1 v_1 = A_2 v_2$ $(1 \times 10^{-4})(v_1) = (0.5 \times 10^{-4})(8.2)$ $v_a = 4.1 \text{ m/s}$
- b) Bernoulli. Position B is the fountain spigot which is open so at atmospheric pressure. $y_1 = 0$ no height.
 $P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$
 $P_1 + 0 + \frac{1}{2} (1000)(4.1)^2 = (1.01 \times 10^5) + (1000)(9.8)(0.5 \text{ m}) + \frac{1}{2} (1000)(8.2)^2$ $P_1 = 1.3 \times 10^5 \text{ Pa}$
- c) Free fall of a water droplet. $v_f^2 = v_i^2 + 2gd$ $(0)^2 = (8.2)^2 + 2(-9.8)(d)$ $d = 3.43 \text{ m}$
- d) Projectile method, in y direction.
 $d_y = v_{iy}t + \frac{1}{2}gt^2$ $d_y = (v_i \sin \theta)t + \frac{1}{2}gt^2$ $0 = (8.2 \sin 60)t + \frac{1}{2}(-9.8)t^2$ $t = 1.45 \text{ sec}$
 X direction. $d_x = v_x t$ $d_x = (v_i \cos \theta)t$ $d_x = (8.2 \cos 60)(1.45)$ $d_x = 5.95 \text{ m}$

SUP1.

- a) $\rho = m/V$ $= 12 / (0.5 \times 0.2 \times 0.2)$ $= 600 \text{ kg/m}^3$
- b) The block will float based on its density. For floating, block weight = buoyant force.
 $m_{\text{obj}}g = \rho_{\text{h20}} V_{\text{disp}} g$ $m_{\text{obj}} = \rho_{\text{h20}} A_{\text{square}}(h_{\text{submerged}})$ $12 = 1000(0.2 \times 0.2)h_{\text{sub}}$ $h_{\text{sub}} = 0.3 \text{ m}$
- c) The extra weight added should equal the extra buoyant force created by submerging the remaining 0.2 m of height.
 $F_{\text{b(extra)}} = \rho_{\text{h20}} V_{\text{disp}} g = (1000)(0.2 \times 0.2 \times 0.2)(9.8) = 78.4 \text{ N}$ $78.4 / 9.8 = 8 \text{ kg of extra mass.}$

SUP2.

- a) Using fluid continuity. $A_1 v_1 = A_2 v_2$ $(4)(10) = (2)(v_2)$ $v_2 = 20 \text{ m/s}$
- b) Bernoulli. $\rho g y_1$ terms cancel out since the pipe stays on the same level.
 $P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$
 $2 \times 10^5 + 0 + \frac{1}{2} (1000)(10)^2 = P_2 + 0 + \frac{1}{2} (1000)(20)^2$ $P_2 = 50000 \text{ Pa.}$

Since P_1 was the gauge pressure and did not include P_o , P_2 will also come out as the gauge pressure.

SUP3.

- a) Bernoulli. $\rho g y_1$ terms cancel out since the height difference is negligible.
 $P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$... rearrange equation so we can find $P_2 - P_1$ which is the ΔP
 $P_2 - P_1 = \frac{1}{2} \rho v_1^2 - \frac{1}{2} \rho v_2^2$ $\Delta P = \frac{1}{2} (1.2) (50^2 - 40^2) = 540 \text{ Pa}$
- b) i) $\Delta P = F_{\text{lift}} / A$ $540 = F_{\text{lift}} / (9 \times 2 \text{ wings})$ $F_{\text{lift}} = 9720 \text{ N}$
 ii) $F_{\text{net}} = 0$ $F_{\text{lift}} = mg$ $9720 = m(9.8)$ $m = 992 \text{ kg.}$

SUP4.

This problem involves floating objects, so weight of object = buoyant force $m_{\text{obj}} g = \rho_{\text{fluid}} V_{\text{disp}} g$

In general ... $m_{\text{obj}} = \rho_{\text{obj}} V_{\text{obj}}$

Giving ... $\rho_{\text{obj}} V_{\text{obj}} g = \rho_{\text{fluid}} V_{\text{disp}} g \quad \dots \quad \rho_{\text{obj}} V_{\text{obj}} = \rho_{\text{fluid}} V_{\text{disp}}$

Water

$$\rho_{\text{obj}} V_{\text{obj}} = \rho_{\text{fluid}} V_{\text{disp}}$$

$$\rho_w V = (1000)(2/3 V)$$

$$\rho_w = 666.67 \text{ kg / m}^3$$

Oil

$$\rho_{\text{obj}} V_{\text{obj}} = \rho_{\text{fluid}} V_{\text{disp}}$$

$$(666.67)V = \rho_{\text{oil}} (9/10 V)$$

$$\rho_{\text{oil}} = 740.74 \text{ kg / m}^3$$

SUP5.

$$\text{a) } P_{\text{abs}} = P_{\text{gauge}} + P_o \quad P_{\text{abs}} = \rho gh + 1.01 \times 10^5 \quad P_{\text{abs}} = (1000)(9.8)(16) + 1.01 \times 10^5 = \quad 260000 \text{ Pa}$$

$$\text{b) Use Bernoulli, same derivation as problem B2005B5 ... } v_2 = \sqrt{2gh} \dots v_2 = \sqrt{2(9.8)(11)} \dots \quad v_2 = 14.7 \text{ m/s}$$

$$\text{c) Using projectile methods.} \quad d_y = v_{iy}t + \frac{1}{2}at^2 \quad -3 = 0 + \frac{1}{2}(-9.8)t^2 \quad t = 0.78 \text{ sec}$$

$$d_x = v_x t = (14.7)(0.78) = 11.5 \text{ m}$$

d) An increase in atmospheric pressure around the dam increases both P_1 and P_2 equally so there is no net effect on these terms in Bernoulli's equation, which means the exit velocity would be the same.