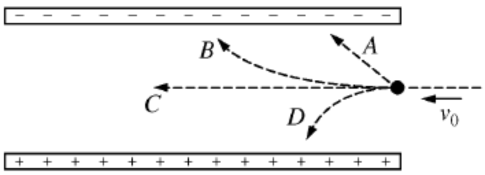
AP2 – Multiple Guess PREX #5 (COMPREHENSIVE) SOLUTIONS

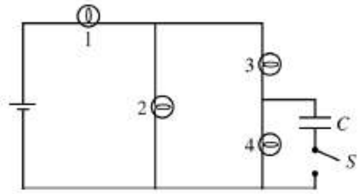
Directions: Do this during class today; TRY NOT TO WORK TOGETHER. I'll forward solutions later today. We will review this on Friday & your Comp Exam will be MONDAY 12/21/2015. NOTE: #'s out of order since I'm C&Ping…



1. A proton is traveling to the left when it enters the space between two oppositely charged parallel plates, as shown above. Which of the four labeled paths will the proton take?

(A) *A*
(B) *B*
(C) *C*
(D) *D*

(B) This option is correct. The motion is analogous to a ball thrown sideways. The ball's horizontal velocity stays constant while the ball gains vertical velocity at a constant rate due to uniform gravitational field, leading to a curved trajectory. The same reasoning applies here, with the uniform electric field making the proton "fall" toward the upper plate.

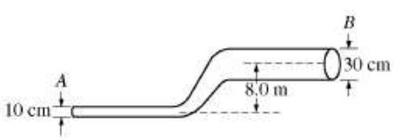


The circuit shown above contains four identical lightbulbs with constant resistance, a capacitor *C*, which is initially uncharged, and a switch *S*. The switch is initially open.

5. Which of the following correctly ranks the potential differences ΔV_1, ΔV_2, ΔV_3, and ΔV_4 across the bulbs while the switch is open?

(A) $\Delta V_1 = \Delta V_2 = \Delta V_3 = \Delta V_4$
(B) $\Delta V_1 > \Delta V_2 = \Delta V_3 = \Delta V_4$
(C) $\Delta V_1 > \Delta V_2 > \Delta V_3 = \Delta V_4$
(D) $\Delta V_1 > \Delta V_2 > \Delta V_3 > \Delta V_4$

(C) This option is correct. Because the current through a bulb is $I = \Delta V_{bulb}/R$, where ΔV_{bulb} is the potential drop across that bulb, and because the resistances are all equal, it follows that the bulb with the greatest current is the bulb with the greatest ΔV_{bulb}. So, ΔV_1 is greatest, by the reasoning of (A). Similarly, because the same current flows through bulbs 3 and 4 in series, ΔV_3 must equal ΔV_4. Because the potential drop between the two junctions is path-independent, the potential drop across bulb 2 must equal the combined potential drop across 3 and 4: $\Delta V_2 = \Delta V_3 + \Delta V_4$. Therefore, ΔV_2 must be greater than ΔV_3 and ΔV_4.



Note: Figure not drawn to scale.

10. Water is flowing with a speed of 9.0 m/s through a pipe of diameter 10 cm. The pipe widens to 30 cm as it goes up an 8.0 m step, as shown in the figure above. If the pressure at point *A* is 2.0×10^5 Pa, what is the pressure at point *B*? (The density of water is 1.0×10^3 kg/m^3.)

(A) 1.2×10^5 Pa
(B) 1.6×10^5 Pa
(C) 2.4×10^5 Pa
(D) 3.2×10^5 Pa

(B) This option is correct. From the continuity equation $(A_1 v_1 = A_2 v_2)$, because the diameter of the pipe triples between A and B, its cross-sectional area increases by a factor of 9, and hence the water's speed at B is one ninth its speed at A, namely 1.0 m/s. From Bernoulli's equation, setting $y = 0$ in the lower pipe, we then get $2.0 \times 10^5\ \text{Pa} + 0 + (1/2)(1.0 \times 10^3\ \text{kg/m}^3)(9.0\ \text{m/s})^2 =$ $P_B + (1.0 \times 10^3\ \text{kg/m}^3)(10\ \text{m/s}^2)(8.0\ \text{m}) + (1/2)(1.0 \times 10^3\ \text{kg/m}^3)(1.0\ \text{m/s})^2$. In solving for P_2, it saves time to neglect the last term on the right-hand side, which is smaller than the other terms, and divide everything through by the density of water, $(1.0 \times 10^3\ \text{kg/m}^3)$.

12. A slab of metal and a slab of wood are placed in a classroom and allowed to sit undisturbed for a long time. A student then places one hand on the metal and the other hand on the wood. Which of the following describes the student's perception of the temperatures of the slabs and their actual temperatures?

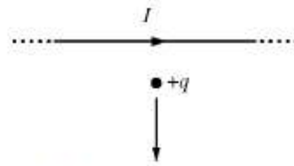
(A) The metal slab feels colder to the student because it is at a lower temperature.
(B) The metal slab feels colder to the student because it conducts thermal energy away from the student's hand faster, but the slabs have the same temperature.
(C) The metal slab feels warmer to the student because it conducts thermal energy to the student's hand faster, but the slabs have the same temperature.
(D) Both slabs feel the same to the student because they are at the same temperature.

(B) This option is correct. The slabs are in thermal equilibrium with the room and at the same temperature, but perception of temperature depends on the rate of thermal energy transfer. Metal has higher thermal conductivity than wood, so it feels colder when touched by the warmer hand of the student.

14. An object with charge $+q$ passes to the right of one pole of a magnet and at a particular instant is moving with a velocity $\vec{v}$ toward the bottom of the page, as shown in the figure above. The force exerted on the object by the magnet at that instant is directed into the page. What is the direction of the force exerted on the magnet by the object?

(A) Out of the page
(B) Toward the right
(C) Toward the top of the page
(D) No direction; the force is zero.

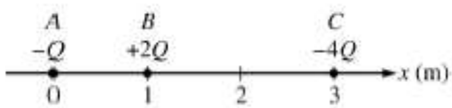
(A)	This option is correct. The force exerted on the moving charged object by the magnet and the force exerted on the magnet by the moving charged object are an interaction described by Newton's third law and have equal magnitudes and opposite directions.



18. The figure above shows a long conducting wire that lies in the plane of the page and carries an electric current I toward the right. At the instant shown, a positive point charge $+q$ is in the plane of the page and moving toward the bottom of the page. What is the direction of the magnetic force on the point charge at that instant?

(A) Into the page
(B) Out of the page
(C) Toward the right
(D) Toward the left

(C)	This option is correct. The magnetic field due to the electric current is directed into the page at the location of the charged object. The force exerted on the moving charge by the field is perpendicular to both the field vector and the velocity vector and for a positive charge is directed to the right.

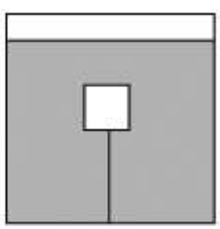


19. The figure above shows three point charges located on an x-axis. Which of the following ranks the magnitude of the net electric force, F, on each point charge due to the other charges?

(A) $F_A = F_C > F_B$
(B) $F_B > F_C = F_A$
(C) $F_A = F_B > F_C$
(D) $F_A > F_C > F_B$

19.

(A)	This option is correct. Assuming force to the right is positive, the net force on A is $-4kQ^2/9 + 2kQ^2/1$. The net force on B is $8kQ^2/4 - 2kQ^2/1$ and the net force on C is $-8kQ^2/4 + 4kQ^2/9$. The question asks for magnitude of net force, so $F_A = F_C = \left\|2kQ^2/1 - 4kQ^2/9\right\|$ and $F_B = 0$.

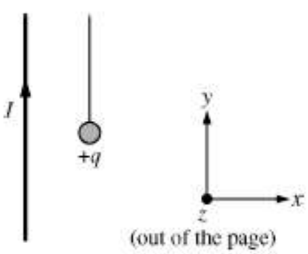


20. A block is submerged in a container of liquid and held under the surface of the liquid by a string connected to the bottom of the container, as shown in the figure above. The tension in the string is not zero. How does the buoyant force F_B exerted by the liquid on the block compare to the block's weight w?

(A) $F_B < w$
(B) $F_B = w$
(C) $F_B > w$
(D) Either $F_B < w$ or $F_B > w$, depending on the density of the liquid.

20.

(C)	This option is correct. Because the block is in static equilibrium, the net force on the block is zero. Net force is the vector sum of buoyant force upward and both tension and weight downward. Therefore, the buoyant force has to be greater than either of the individual downward forces.



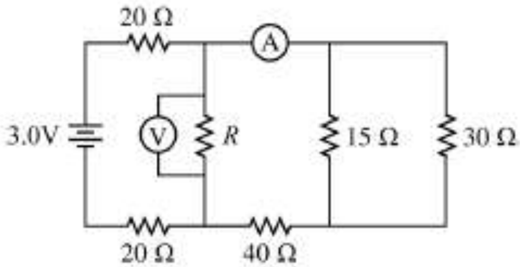
31. The figure above shows a long, straight wire that has a steady current I in the $+y$-direction. A small object with charge $+q$ hangs from a thread near the wire. A student wants to investigate the magnetic force on the object due to the current but is not able to observe or measure changes in the tension in the string. Of the following actions that the student can take, which will allow the student to observe a reaction of the object due to the magnetic force on it?

(A) Holding the object motionless
(B) Moving the object in a circle that is centered on the wire and in the x-z plane
(C) Moving the object in the $-x$-direction
(D) Moving the object in the $+y$-direction

31.

(D)	This option is correct. With the direction of current given, using a right hand rule, the magnetic field near the small object is directed into the page (in the $-z$ direction). Using a right hand rule and $F_B = qv_\perp B$, moving the object in the $+y$ direction will produce a magnetic force on the object in the $-x$ direction, which the students should be able to observe.

Questions 37-38 refer to the following material.

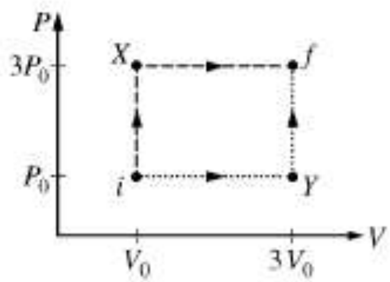


In the circuit shown above, the current through the ammeter is 20 mA and the voltmeter indicates 1.0 V.

37. What is the current through the 40 Ω resistor?

(A) 7.5 mA
(B) 10 mA
(C) 20 mA
(D) 40 mA

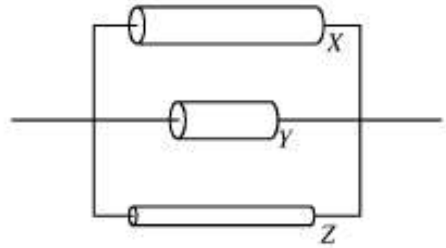
(C)	This option is correct. The 40 ohm resistor and the ammeter are located in equivalent positions in the circuit. No matter what the direction of current through the ammeter, it will split at one of the junctions on either side of the ammeter, and recombine when it reaches the corresponding junction on either side of the 40 ohm resistor. So the 40 ohm resistor also has a current of 20 mA.



47. A sample of an ideal gas can be taken from state *i* to state *f* via two processes, as shown in the above graph of pressure *P* versus volume *V*. In one process the gas goes through state *X*, and in the other process the gas goes through state *Y*. Which of the following will be the same for both processes? Select two answers.

(A) The change in the internal energy of the gas
(B) The temperature of the gas at the end of the process
(C) The thermal energy transferred to the gas by heating
(D) The work done on the gas

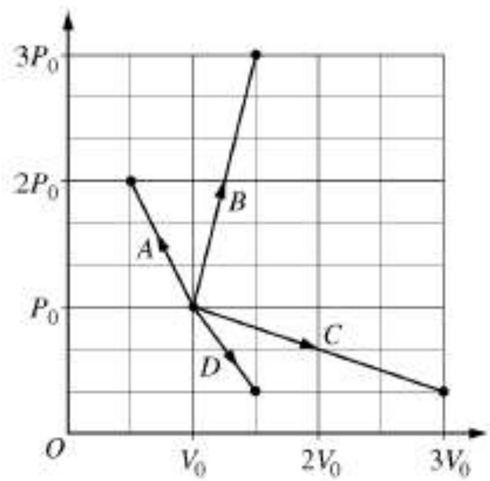
(A)	This option is correct. The change in internal energy of the gas depends only on change in temperature ($\Delta U = \Delta T$). The difference in temperature between point *i* and point *f* will be the same, regardless of path.
(B)	This option is correct. Temperature at each point depends on the pressure and volume at that point ($PV = nRT$). The temperature at point *f* will be determined by P and V at that point, not on the path during the process.



39. The figure above represents a section of a circuit containing three resistors, *X*, *Y*, and *Z*, of different sizes but made of the same material. Which of the following correctly ranks the current in the resistors?

(A) $I_Z > I_X > I_Y$
(B) $I_Z = I_X > I_Y$
(C) $I_Y = I_X = I_Z$
(D) $I_Y > I_X > I_Z$

(D)	This option is correct. Current is proportional to the cross sectional area of the conductor and inversely proportional to length of the conductor. Conductors X and Y have the same cross sectional area and Y has clearly the smaller length. Conductors X and Z have the same length, but X has a larger cross sectional area. This leads to the conclusion that $I_y > I_x > I_z$.



48. Identical samples of gas initially have pressure P_0, volume V_0, and temperature T_0. In some experiments, students take samples through each of the processes shown in the graph above. The final temperature is equal to the initial temperature for which of the processes? Select two answers.

(A)	This option is correct. Use the ideal gas law, $PV = nRT$; therefore $T = PV/nR$. Because n and R are constant for these samples, we only need to examine the product PV in each case. For process A, the initial product is P_0V_0 and the final product is $(1/2P_0)(2V_0)$, so the products are equal and temperature does not change.
(B)	This option is incorrect. For process B, the initial product is P_0V_0 and the final product is $(3P_0)(1.5V_0)$, so they are not equal and thus the temperature changes.
(C)	This option is correct. Use the ideal gas law, $PV = nRT$, so $T = PV/nR$. Because n and R are constant for these samples, we examine only the product PV in each case to see if T is constant. For process C, the initial product is P_0V_0 and the final product is $(1/3P_0)(3V_0)$, so the products are equal and temperature does not change.