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Solutions - PHYS 251 Exam 2 - Practice Test

1A

Where the density of the field lines has been halved, we can assume the electric field is half its original value. Since the force is proportional to the field strength, when the field is halved, so too is the force, thus it becomes 5 pN. Also, since we have switched from a proton to an electron, the charge has flipped and so too must the direction of the force, thus we move to the right instead of the left.

2E

If the ball is attracted to the rod, it must be made of a conductive material, otherwise it would not have been influenced by the nearby positive charge. The reason it is then attracted to the rod is due to “induction”, where the electrons rearrange themselves to be as close to the positive charge as possible (or as far away from the negative charge if the rod was negatively charged). Thus we pick answer choice E.

3A

Remember that according to Coulombs Law the force acting on each sphere will be equal in size but acting in opposite directions. This is why they repel. Since the forces acting on each sphere have the same magnitude, and since the spheres have the same mass as well, the acceleration acting on each sphere will also be the same (this is comes from Newton’s second law: F = ma). Thus if they each experience the same acceleration, they will move the same distance apart from each other, and answer choice A is the correct choice depicting that.

4E

We use Coulomb's law to determine the force on the negative charge due to the other two charges located on either side:

The force due to the +50μC charge is:

$$F_1 = \frac{k(50\mu C)(40\mu C)}{2^2} = 4.495N, \text{ in the } -\text{x direction}$$

where the distance is 2m based on the location of each charge along the x-axis.

The force due to the +30μC charge is:

$$F_2 = \frac{k(30\mu C)(40\mu C)}{2^2} = 2.697N, \text{ in the } +\text{x direction}$$

where the distance is 2m based on the location of each charge along the x-axis.

Thus the net force is $F_1 + F_2$ = (-4.495 + 2.697) = -1.798 N along the x-axis.

5A

To answer this, we must use Coulomb's law to determine the magnitude and direction of each force acting on q1 from the other charges:

$$F_{12} = \frac{k(20\mu C)(20\mu C)}{2^2} = 0.899N, \text{ in the } +\text{y axis}$$

$$F_{13} = \frac{k(20\mu C)(40\mu C)}{2^2} = 1.798N, \; 30^\circ \text{ above the } -\text{x axis}$$

Note that we know the force from q3 is 30^0 above the –x axis since all the charges form an equilateral triangle 60 degrees apart.

In order to get the correct magnitude, we must first take the forces and place them in the respective x- and y-components:

> F_{12} is already along the y-axis, so need not be altered.
> $F_{13,x\ axis} = F_{13}\cos 30 = 1.56N$, $F_{13,y\ axis} = F_{13}\sin 30 = 0.899N$

Thus using vector analysis we see that the total force along each axis is:

> y-axis: 0.899 + 0.899 = 1.798 N
> x-axis: 1.56 N

The magnitude using Pythagorean theory: $F = \sqrt{(1.798)^2 + (1.56)^2} = 2.38N$

Thus we choose answer choice A.

6D

The general equation for electric field is E = F/Q, where represents a test charge placed in the field. So if we solve this equation for force, we get:

> $F = EQ = (200)(-1.6 \times 10^{-19}) = -3.2 \times 10^{-17}$

The charge is based on the charge of an electron (given on your test's data sheet) and since it is negative, it must travel in the opposite direction of the field, thus we choose answer choice D.

7E

The only equation relating potential energy and electric potential is $\Delta V = \Delta U/q$.

This means to calculate the change in potential energy, we need to multiply ΔV with q. Note that in this particular problem, q represents the negative charge that is moved from the x-axis to the y-axis.

The change in electric potential, ΔV, is a scalar quantity that is essentially only interested in the fixed point charge and its distance, r, where we measure the potential. In this particular problem, the initial and final locations of the moving charge are the same distance from the fixed charge, thus the potential at each location is identical. This means that the change in potential as the negative charge moves from its initial to its final location is zero, and thus the change in potential energy is also zero.

8D

This scenario is indicative of a positive point charge, which decreases in field strength the further you are from it. The potential of such a point charge will also decrease as you move away from the charge, and thus answer D is the appropriate choice.

9B

Positive charges always move in the direction of the electric field. The resulting motion always moves the positive charge from a region of higher to potential to one of lower potential, and so its electric potential energy decreases accordingly.

10E

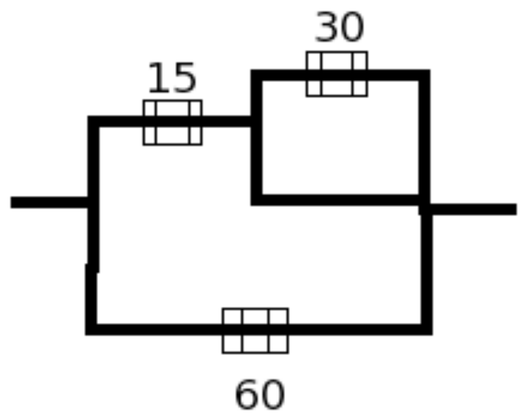
In order to use the equation for discharging, we should consider the amount of charge *remaining* after three time constants, which would have to be $q(t)/q_0$. Also we can substitute time, t, with 3τ, which is three time constants. We can also substitute RC, which is also equal to τ, and we get:

$$\frac{q(t)}{q_0} = e^{\frac{-t}{RC}} = e^{\frac{-3\tau}{\tau}} = e^{-3} = 0.0498 = 4.98\%$$

This means that after three time constants, we have 4.98% left, which means that charge has been reduced by 95.02%.

Note that the fact that charge had been reduced by 63% after one time constant was useless information if you solve it this way.

11D
Using the appropriate equations for resistors in parallel, the two resistors at the top left of the circuit can be combined into equivalent resistance of 15 ohms. Also, the two resistors in series at the bottom are the equivalent of 60 ohms. Thus the circuit can be redrawn as shown below:



At this stage the current can get from “a” to “b” by travelling through either the 15 ohm resistor or the 60 ohm resistor. It does not need to go via the 30 ohm resistor at the top right. Which means that for all intents and purposes we can ignore it. So now we really have a simple parallel circuit with resistors of 15 and 60 ohms, and an equivalent resistance of 12 ohms.

12D
Looking at the currents entering and leaving any of the junctions where the wires meet gives the following equation: $I_2 + I_3 = -I_1$.
This can be rewritten to get answer D.

13D
We treat the resistors in series on the top half of the circuit as one resistor of 12 ohms, and the resistors at the bottom as one resistor of 596 ohms. So the circuit is really a parallel circuit with equivalent resistance of 11.8 ohms.

14D
The voltage drops from 9 V to 8.5 V due to the internal resistance. This 0.5 V lost within the battery can be set equal to V = IR, allowing us to solve for the current, I, to get:

$$I = V/R = 0.5/0.1 = 5 \text{ A}$$

15D
Energy dissipation is the same thing as power. So let's see the equations for power:

$$P = V_0 I = I^2 R = \frac{V^2}{R}$$

We can analyze each answer choice as follows:

(a) False – if you half V (with R constant) the power decreases by a factor of one fourth.
(b) False – if you half I (with R constant) the power decreases by a factor of one fourth.
(c) False – if you half R (with V constant) the power will double.
(d) True – according to $P = I^2R$, if you half R (with I constant) the power will half.
(e) False – if you half both V and I the power decreases by a factor of one fourth..

16C
Remember that the capacitance is decided once the capacitor is built, and cannot be changed after that point. Thus, plate separation, plate area, and the insertion of a dielectric material, are the only factors that influence capacitance.

17D
Initially, the capacitor will not affect the resistance of the circuit, and you can pretend that it is not even there. Thus the current in the circuit will be I = V/R, regardless of the capacitance, and is thus 18/2 = 9 Amps.

18C
Remember that resistivity is a property of a material, and so both wires have the same resistivity (this rules out A).

The graph shows that at any given voltage the current in wire A is greater than that of wire B. This can only happen if wire A has a smaller resistance, since current and resistance are inversely proportional. That means that statement ii is correct. We should also remember that if everything else is held constant, the shorter the conductor is, the smaller the resistance will be. So since wire A has the smaller resistance, we can assume it has a shorter length, and thus statement v is also correct.