Solutions

QUIZ 1 – 1999

(1) A copper wire and an iron wire of the same length, L = 10 meters, and diameter, d =2.0 mm are joined together in series and a potential difference of 100 V is applied between the ends of the composite wire [$\rho_{iron} = 1.0 \times 10^{-7}$ Ω-m and $\rho_{Cu} = 1.7 \times 10^{-8}$ Ω-m].
Find:
(a) the total resistance in the composite wire (8 points).

$R_{Cu} = \frac{(1.7\times10^{-8}\,\Omega m)(10)}{\pi/4\,(2)^2\times10^{-6}} = 54\ m\Omega$

$R_{Fe} = 318\ m\Omega \Rightarrow R_{total} = 372\ m\Omega$

(b) the power dissipated in each wire (8 points)

$P_{Cu} = I^2 R_{Cu} = \frac{(100)^2}{(0.372)^2}\cdot 54\times10^{-3} = 3.9\ kW$

$P_{Fe} = I^2 R_{Fe} = 23.0\ kW$

$P_{total} = 26.9\ kW$

(c) Given the two pieces of wire separately would you connect them in series or in parallel to maximize the power dissipated ? Calculate the difference in the power dissipated (6+3 points) ?

Parallel $\Rightarrow$ $P_{total} = \frac{(100)^2}{R_{Cu}} + \frac{(100)^2}{R_{Fe}}$

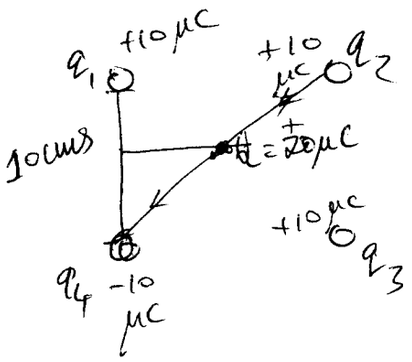
$= 185\ kW + 31.4\ kW$

$P_{total} = 216.4\ kW$

Diff = 189.5 kW

(2) Three identical charges $q_1=q_2=q_3$ = +10 μC and a fourth charge q_4 = -10 μC are fixed at the corners of a square of side a = 10 cms. A test charge Q = 20 μC is placed at the center of the square. [Given $k=(4\pi\varepsilon_0)^{-1}=9 \times 10^9$ N.m^2/C^2]

(a) What is the magnitude and the direction of the electric force on Q ? (15 points)

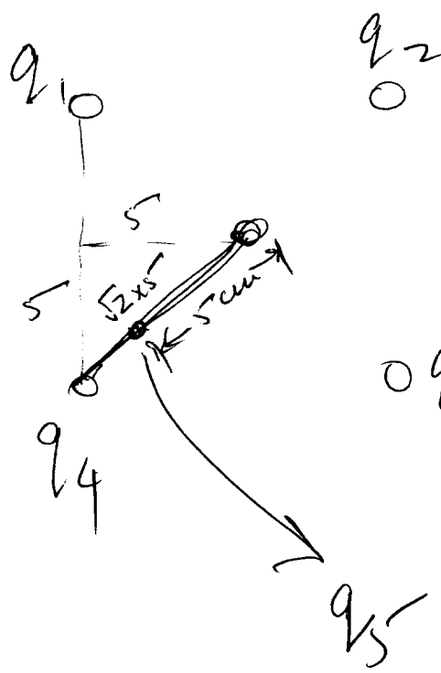


$$F_{total} = \frac{(20)(20)\times10^{-6}\times10^{-6}\times9\times10^{9}}{2\times(5)^2\times10^{-4}}$$

$$|\vec{F}| = \frac{18\times1000}{25} = 720\ N$$

Direction is along diagonal line connecting q_4 and Q.

(b) You are given an additional charge q_5= +10 μC. Where would you place this charge such that the net force on Q is zero? (10 points).



$$\frac{2}{(\sqrt{2}\times5)^2} = \frac{1}{r^2}$$

or $r = 5$ cm away from Q on the line between Q & q_4