University of Bahrain
College of Science
Dept. of Physics

PHYCS 102
Final Exam

Summer 02/03
Date: 20/8/2003
Time:8:30-10:30

Name:---ID no.------------------------------------Sec.no.--------

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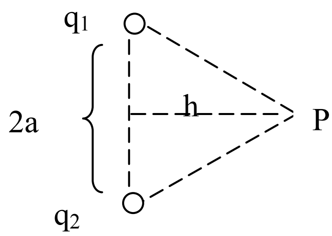
1) Two small beads having charges $q_1 = (0.5, 1.0, 1.5, 2.0)$ nC and $q_2 = (-0.5, -1.0, -1.5, -2.0)$ nC are fixed as shown in the figure, where h = 4 cm and a = 3 cm. Find the magnitude of the net electrostatic field (in N/C) at point "P".



a) 2.16×10^3 b) 4.32×10^3 c) 6.48×10^3 d) 8.64×10^3

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2) A uniformly charged insulating rod is bent into the shape of quarter circle of radius 10 cm. The rod has a total charge of (-2.0, -4.0, -6.0, -8.0)nC. Find the magnitude of the electric field (in N/C) at "O", the center of the arc.

a) 1.62×10^3 b) 3.24×10^3 c) 4.8×10^3 d) 6.48×10^3

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3) A solid insulating sphere of radius 10 cm carries a net positive charge of (10.0, 15.0, 20.0, 25.0)nC, uniformly distributed throughout its volume. Find the electric potential difference (in V) between the center and the surface of the sphere.

a) 450.0 b) 675.0 c) 900.0 d) 1125.0

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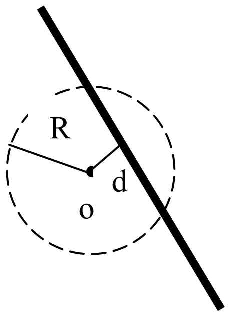
4) An infinitely long line charge having a uniform charge per unit length $\lambda = 200$ nC/m lies a distance d = (1, 8, 12, 18) cm from a point "O", as shown in the figure. Determine the total electric flux (in V.m) through the surface of a sphere of radius R = 20 cm centered at "O".



a) 9.03×10^3 b) 8.28×10^3 c) 7.23×10^3 d) 3.94×10^3

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5) A point charge (15.0, 20.0, 25.0, 30.0) nC is placed at the center "O" of a conducting spherical shell with inner radius 10 cm and outer radius 15 cm, and having a net charge of (-8 nC) . What is the magnitude of the electric potential (in V) at point "P" located 20 cm from "O"?

a) 315.0 b) 540.0 c) 765.0 d) 990.0

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6) A long cylindrical conductor of radius a = 5 cm and line charge density λ_a = (4, 8, 12, 16) nC/m is coaxial with a cylindrical shell of negligible thickness, radius b = 15 cm, and line charge density equal to $(-\lambda_a)$. Find the potential difference (in V) between the two cylinders.

a) 79.1 b) 158.2 c) 237.3 d) 316.4

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7) A parallel – plate, air – filled capacitor of capacitance C = 3pF is charged with a battery to a potential difference of 8V. The battery is then removed, and the air gap of the capacitor is filled with an insulator of dielectric constant (2.1, 3.2, 4.3, 5.4). Find the change in the energy stored (in Pico Joules – pJ) in the capacitor before and after the dielectric is inserted.

a) 50.3 b) 66.0 c) 73.7 d) 78.3

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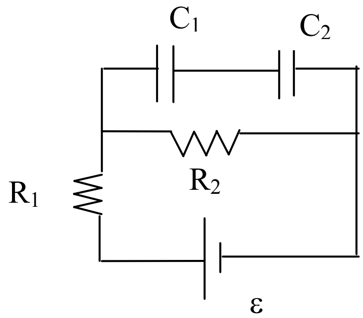
8) Two capacitors C_1 = (1.0, 2.0, 3.0, 4.0) μF and C_2 = 5 μF are connected as shown in the nearby circuit, where R_1 = 10 Ω, R_2 = 40 Ω, and ε = 100 V. Find the charge (in μC) of the capacitor C_2.



a) 66.67 b) 114.28 c) 150.0 d) 177.78

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9) A current of 1.8 A flows in a copper wire at 20 °C. Find the decrease in the current (in A) when its temperature increases to (50, 70, 90, 120)°C .

a) 0.3 b) 0.46 c) 0.58 d) 0.73

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10) An alternating voltage source has a peak (maximum) of 120V is used across a copper wire of (20, 40, 50, 80) km length and 2 mm in diameter. Find the (rms) value of the current (in A) in the wire.

a) 0.83 b) 0.42 c) 0.34 d) 0.21

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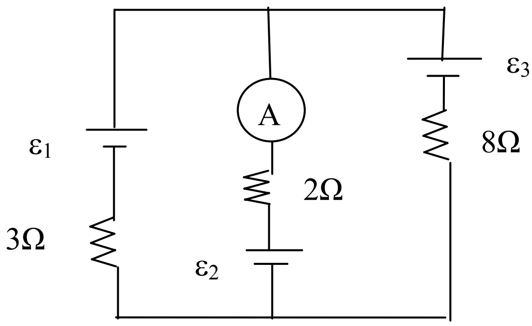
11) In the circuit shown ε_1 = 2V, ε_2 = (5, 6, 7, 8)V , and ε_3 = 9V. What is the reading of shown ideal ameter (in A)?



a) 0.26 b) 0.50 c) 0.74 d) 0.98

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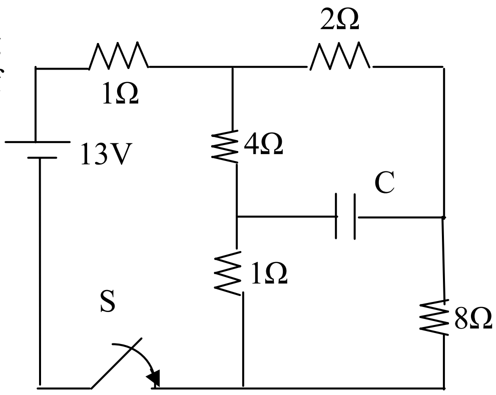
12) In the shown circuit, if the switch (S) is closed for a long time, find the charge (in μC) on the capacitor C of capacitance (1.5, 3, 4.5, 6) μF.



a) 9 b) 18 c) 27 d) 36

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13) In the previous circuit of question 12, if the switch S is now opened at t = 0, find the time (in μs) required for the capacitor to lost (25%, 35%, 45%, 55%) of its initial charge.

a) 1.6 b) 4.7 c) 9.7 d) 17.3

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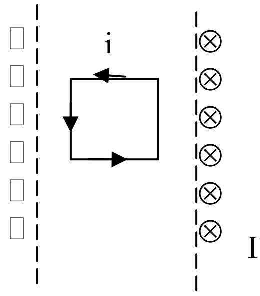
14) A long solenoid has n = 500 turns per meter and carries a current I = 15A. Inside the solenoid is a square coil that has a dimension of 6.0 cm and consists of a total N = 250 turns of fine wire carries a current of i = (0.1, 0.23, 0.34, 0.45) A. The plane of the coil is parallel to the axis of the solenoid as shown in the figure. Find the magnitude of the torque (in N.m) acting on the coil.



a) 8.48×10^{-4} b) 1.95×10^{-3} c) 2.88×10^{-3} d) 3.82×10^{-3}

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15) A beam of electrons is accelerated from rest through a potential difference of 500 V. The beam enters a perpendicular magnetic field of B = (1.0, 2.3, 3.4, 4.3)mT. Find the radius (in cm) of the circular orbit of the beam.

a) 7.54 b) 3.28 c) 2.22 d) 1.75

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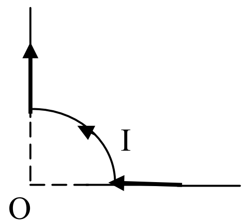
16) A segment of wire shaped in a form of arc that subtends an angle of 90° and of radius 0.25 m as shown in the nearby figure. The wire carries a current of (10, 13,16, 18)A . Determine the magnitude of the magnetic field (in μT) at the origin "O".



a) 6.28 b) 8.17 c) 10.05 d) 11.31

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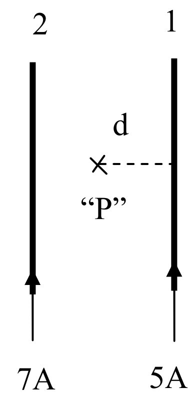
17) Two long parallel thin wires (1 and 2) are separated by (210, 186, 150, 126) mm and carry currents 5A and 7A, respectively in the same direction, as shown in the figure. Find the location d (in mm) of the point "P" relative to wire (1) that has zero magnetic field.



a) 87.5 b) 77.5 c) 62.5 d) 52.5

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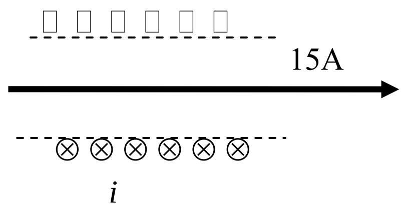
18) A long straight thin wire carries a current of 15A is placed on the axis of a long solenoid of 200 turns/meter and radius 2 cm. A current *i* of (1.2, 1.8, 2.5, 3.1) A is sent through the solenoid. Find the magnitude of the total magnetic field (in T) at a distance 5 mm from the solenoid axis.



a) 6.72×10^{-4} b) 7.52×10^{-4} c) 8.69×10^{-4} d) 9.83×10^{-4}

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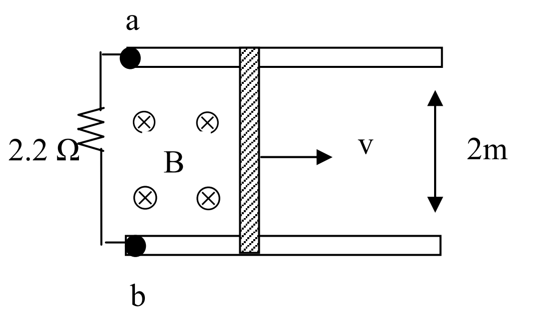
19) A conducting rod slides with a velocity v = 1.8 m/s on two long frictionless and resistanceless parallel rails a distance of 2.0 m apart in a uniform perpendicular magnetic field B = (1.3, 2.4, 3.5, 4.6)T, as shown in figure. Find the induced current (in A) in the circuit.



a) 2.13 b) 3.93 c) 5.73 d) 7.53

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20) A magnetic field of 0.02T makes an angle of (37^o, 53^o, 90^o, 70^o) with the normal on a rectangular loop of area 0.4 m^2. If the orientation of the loop changes to 0^o within 0.2 s, find the average magnitude of the induced emf (in mV) in the loop.

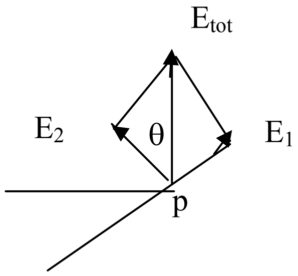
a) 8.1 b) 15.9 c) 40.0 d) 26.3

$\varepsilon_o = 8.85\times10^{-12} C^2/N.m^2$, $K = 9 \times 10^9 \, N.m^2/C^2$, $e = 1.6\times10^{-19} C$, $m_{e\ell} = 9.1\times10^{-31} kg$

$\rho_{copper} = 1.6\times10^{-8}\,\Omega.m$, $\alpha_{copper} = 6.8\times10^{-3}\,{}^oC^{-1}$,

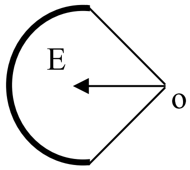
$\mu_o = 4\pi\times10^{-7} T.m/A$

Solution **Final exam PHYCS 102** **Summer2003**



1) $E_1 = E_2 = Kq/r^2 = 1800 N/c$

$$E_{tot} = 2E_1 \cos\theta = 2\varepsilon_1(3/5) = 2160 \ N/C$$



2) $E_{arc} = \frac{2K\lambda}{R}\sin 45, \quad Q = \lambda\left(\frac{2\pi R}{4}\right)$

$$E_{arc} = \frac{4QK \ \sin \ 45}{\pi R^2} = 1620.5 \ N/C$$

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3) $E_{in} = \frac{\rho r}{3\varepsilon_o}, \quad V_{os} = \int_o^R \varepsilon dr = \frac{\rho R^2}{6\varepsilon_o} = \frac{KQ}{2R} = 450 \ V$ **, "O": center, "S": surface point.**

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4) $L = 2\sqrt{R^2 - d^2}, \ \Phi = \frac{\lambda L}{\varepsilon_o} = 9028.24(mks)$

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5) $Vp = \frac{KQ_{tot}}{0.2} = 45\times10^9 \times \ Q_{tot} = 45\times10^9(15-8)10^{-9} = 315 \ V$

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6) cylindrical capacitor.

$$V_{ab} = \int_a^b Edr = \frac{\lambda}{2\pi\varepsilon_o}\int_a^b \frac{dr}{r} = 2K\lambda\ell n\left(\frac{b}{a}\right) = 79.1 \ V$$

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7) $U_{before} = \frac{Q^2}{2C_o}, \ U_{after} = \frac{Q^2}{2kC_o} \quad \therefore \Delta U = \frac{Q^2}{2C_o}\left(1 - \frac{1}{k}\right) = 50.3 \ \ pC$

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8) $I = \frac{\varepsilon}{R_1 + R_2} = 2A, \quad V_{R_2} = 2\times40 = 80V$

$$\left.\begin{matrix} 80 = V_1 + V_2 \\ 1\times V_1 = 5\times V_2 \end{matrix}\right\} \Rightarrow V_2 = 13.34 \ V, \quad Q_2 = C_2V_2 = 66.67 \ \ \mu C$$

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9) $\Delta I = I_{50} - I_{20} = \frac{V}{R_{50}} - \frac{V}{R_{20}} \ , \quad R_{50} = R_{20}\left[1 + 6.8\times10^{-3}(50-20)\right]$

$$\Delta I = \frac{V}{R_{20}}\left[\frac{1}{1+6\times10^{-3}\times30} - 1\right] = 1.8[-0.169] = -0.3 \ A$$

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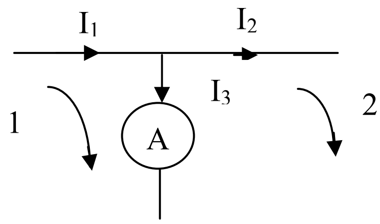
10) $R = \frac{\rho L}{A} = \frac{1.6\times10^{-8}\times20\times10^3}{\pi\left[1\times10^{-3}\right]^2} = 101.86 \ \Omega$

$$I_{rms} = \frac{V_{rms}}{R} = \frac{120/\sqrt{2}}{101.86} = 0.83\ A$$



11)

$$\left.\begin{aligned} & I_1 = I_2 + I_3 \\ (1)\ & 3I_1 + 2I_3 = -5 + 2 \\ (2)\ & 8I_2 - 2I_3 = -9 + 5 \end{aligned}\right\} I_3 = -0.26A$$

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12)

$$I = \frac{13}{R_{tot}} = \frac{13}{1 + \frac{(1+4)(2+8)}{(1+4)+(2+8)}} = 3A$$

$$\left.\begin{aligned} 3 &= I_{2\Omega} + I_{4\Omega} \\ 5I_{4\Omega} &= 10I_{2\Omega} \end{aligned}\right\} \Rightarrow \begin{aligned} & I_{2\Omega} = 1A,\quad I_{4\Omega} = 2A \\ & V_{2\Omega} = 2V,\ V_{4\Omega} = 8V \\ & V_c = 8 - 2 = 6V\ \therefore Q = 9\mu C \end{aligned}$$

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13)

$$\tau = RC = \frac{(4+2)(1+8)}{(4+2)+(1+8)} \times 1.5 = 3.6 \times 1.5 = 5.4\mu s$$

$$Q = Q_o e^{-t/\tau}\ \therefore t = \tau \ell n\left(\frac{Q_o}{Q}\right) = \tau \ell n\left(\frac{Q_o}{0.75Q_o}\right) = 1.55\mu s$$

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14)

$$B = \mu_o n I = 9.4 \times 10^{-3} T$$

$$\tau = \mu B = \left(250 \times 36 \times 10^{-4} \times 0.1\right)\left(9.4 \times 10^{-3}\right) = 8.48 \times 10^{-4}\ N.m$$

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15)

$$eV = \frac{1}{2} m v^2\ ,\ v = 1.326 \times 10^7\ m/s$$

$$R = \frac{mv}{qB} = 7.54\ cm$$

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16)

$$B_{arc} = \frac{\mu_o I}{4\pi R^2} L = \frac{\mu_o I}{4\pi R} \theta_{rad} = \frac{\mu_o I}{8R} = 6.28\mu T$$

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17)

$$B_1 = B_2 \quad , \quad \frac{\mu_o I_1}{2\pi d} = \frac{\mu_o I_2}{2\pi(210 - d)} \Rightarrow d = \frac{I_1}{I_1 + I_2} \times 210 = 87.5mm$$

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18)

$$B_{solenoid} = \mu_o n i = 3.0 \times 10^{-4} T,\ B_{wire} = \frac{\mu_o I}{2\pi d} = 6 \times 10^{-4} T$$

$$B_{tot} = \left[B_{solenoid}^2 + B_{wire}^2\right]^{1/2} = 6.72 \times 10^{-4} T$$

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19)

$$I = \frac{\varepsilon_{in}}{R} = \frac{BLv}{R} = \frac{(1.3)(2)(1.8)}{2.2} = 2.13A$$

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20) $$\overline{\varepsilon_{in}} = -\frac{\Delta\phi}{\Delta t} = -\frac{\phi_2 - \phi_1}{\Delta t} = -\frac{BA\left(\cos\theta_2 - \cos\theta_1\right)}{0.2} = -8.1mV$$
