PHYSICS 2B | QUIZ 5 | WINTER QUARTER 2010
PROF. HIRSCH | FEBRUARY 22, 2010

Formulas:

$\sin 30^\circ = \cos 60^\circ = 1/2$, $\cos 30^\circ = \sin 60^\circ = \sqrt{3}/2$, $\sin 45^\circ = \cos 45^\circ = \sqrt{2}/2$

$F = k\frac{q_1 q_2}{r^2}$ Coulomb's law ; $k = 9\times 10^9 \mathrm{N\cdot m^2/C^2}$; $\vec{F}_{12} = \frac{kq_1q_2}{|\vec{r}_2 - \vec{r}_1|^3}(\vec{r}_2 - \vec{r}_1)$

Electric field due to charge q at distance r: $\vec{E} = \frac{kq}{r^2}\hat{r}$; Force on charge Q: $\vec{F} = Q\vec{E}$

Electric field of dipole: along dipole axis / perpendicular: $E = \frac{2kp}{x^3}$ / $E = \frac{kp}{y^3}$ (p=qd)

Energy of and torque on dipole in E-field: $U = -\vec{p}\cdot\vec{E}$, $\vec{\tau} = \vec{p}\times\vec{E}$

Linear, surface, volume charge density: $dq = \lambda\, ds$, $dq = \sigma\, dA$, $dq = \rho\, dV$

Electric field of infinite: line of charge: $E = \frac{2k\lambda}{r}$; sheet of charge: $E = 2\pi k\sigma = \sigma/(2\varepsilon_0)$

Gauss law: $\Phi = \oint \vec{E}\cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$; Φ = electric flux ; $k = \frac{1}{4\pi\varepsilon_0}$; $\varepsilon_0 = 8.85\times 10^{-12} C^2/Nm^2$

$U_B - U_A = \Delta U_{AB} = -W_{AB} = -\int_A^B \vec{F}\cdot \vec{dl} = -\int_A^B q\vec{E}\cdot\vec{dl} = q\Delta V_{AB} = q(V_B - V_A)$ V=N/C

$V = \frac{kq}{r}$; $V = \int \frac{kdq}{r}$; $V = \frac{kp\cos\theta}{r^2}$ (dipole) ; $E_l = -\frac{\partial V}{\partial l}$; $\vec{E} = -\vec{\nabla} V$

Electrostatic energy: $U = k\frac{q_1q_2}{r}$; Capacitors: $Q = CV$; with dielectric: $C = \kappa C_0$; $\varepsilon_0 = 8.85\, pF/m$

$C = \frac{\varepsilon_0 A}{d}$ parallel plates ; $C = \frac{2\pi\varepsilon_0 L}{\ln(b/a)}$ cylindrical ; $C = 4\pi\varepsilon_0\frac{ab}{b-a}$ spherical

Energy stored in capacitor: $U = \frac{Q^2}{2C} = \frac{1}{2}QV = \frac{1}{2}CV^2$; $U = \int dv\, u_E$; $u_E = \frac{1}{2}\varepsilon_0 E^2$

Capacitors in parallel: $C = C_1 + C_2$; in series: $C = C_1C_2/(C_1+C_2)$

Elementary charge: $e = 1.6\times 10^{-19} C$

$I = \frac{dq}{dt} = \int \vec{J}\cdot d\vec{A}$; $\vec{J} = ne\vec{v}_d$; $v_d = \frac{eE\tau}{m}$; $\rho = \frac{m}{ne^2\tau}$; $R = \rho\frac{\ell}{A}$; $\vec{E} = \rho\vec{J}$, $\vec{J} = \sigma\vec{E}$

$V = IR$; $P = VI = I^2R = V^2/R$; $P_{emf} = \varepsilon I$; $R_{eq} = R_1 + R_2$ (series) ; $R_{eq}^{-1} = R_1^{-1} + R_2^{-1}$ (parallel)

Charging capacitor: $Q(t) = C\varepsilon(1 - e^{-t/RC})$; Discharging capacitor: $Q(t) = Q_0 e^{-t/RC}$

Force on moving charge: $\vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$; force on wire: $d\vec{F} = Id\vec{\ell}\times\vec{B}$

Circular motion: $a = \frac{v^2}{r}$; radius $r = \frac{mv}{qB}$; period $T = \frac{2\pi m}{qB}$

Magnetic dipole: $\vec{\mu} = I\vec{A}$; torque: $\vec{\tau} = \vec{\mu}\times\vec{B}$; energy: $U = -\vec{\mu}\cdot\vec{B}$

Biot-Savart law: $d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{\ell}\times\hat{r}}{r^2}$; $\mu_0 = 4\pi\times 10^{-7}\frac{N}{A^2}$; Ampere's law: $\oint \vec{B}\cdot d\vec{\ell} = \mu_0 I_{enc}$

Long wire: $B = \frac{\mu_0 I}{2\pi r}$; loop, along axis: $B = \frac{\mu_0 I a^2}{2(a^2+z^2)^{3/2}}$; dipole: $\vec{B} = \frac{\mu_0}{2\pi}\frac{\vec{\mu}}{x^3}$

solenoid: $B = \mu_0 In$; toroid: $B = \frac{\mu_0 NI}{2\pi r}$; Gauss law for magnetism: $\oint \vec{B}\cdot d\vec{A} = 0$

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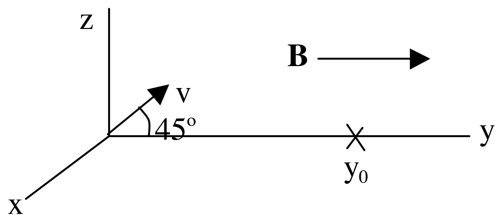
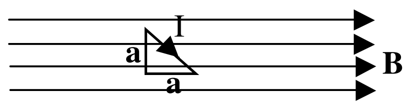
<u>There are 8 problems. You get 1 point for correct answer, 0 points for incorrect answers, 0.2 points for no answer (up to 5 non-answers). This is Test Form A</u>

Problem 1



A particle of mass 3kg and charge 2C starts at the origin (x,y,z)=(0,0,0) with velocity v in the yz plane at 45^0 with respect to the y axis as shown in the figure. There is a uniform magnetic field B pointing along the y direction everywhere. After 3 seconds, the x-coordinate of the particle is -12m. After another 3 seconds the particle hits the y-axis again for the first time after it left the origin, i.e. is at the point $(0,y_0,0)$. The value of y_0 expressed in meters is
(a) 6π ; (b) 18π ; (c) 24π ; (d) 12π ; (e) 2π

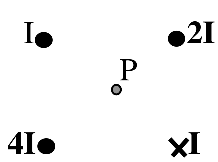
Problem 2



The loop in the figure has two sides of length a=0.7m that join at a 90 degree angle and is in a uniform magnetic field B=2T oriented as shown in the figure. A current I=1.4A circulates through the loop in the direction shown. The magnitude of the force on the long side of the loop is
(a) 2N ; (b) 1.4N ; (c) 2.8N ; (d) 2.4N ; (e) 1.7N

Problem 3
For the situation in Problem 2, the magnetic field generated by the current loop at a distance d=10m in direction perpendicular to the paper has magnitude approximately
(a) 0.2×10^{-10}T ; (b) 0.4×10^{-10}T ; (c) 0.5×10^{-10}T ; (d) 0.6×10^{-10}T ; (e) 0.7×10^{-10}T

Problem 4



The four long wires shown are oriented <u>perpendicular to the paper</u> in a square arrangement and carry currents of magnitude shown in or out of the paper as shown. The magnetic field at point P located at the center of the square points:
(a) to the right ; (b) to the left ; (c) up ; (d) down ; (e) at 45° angle to horizontal

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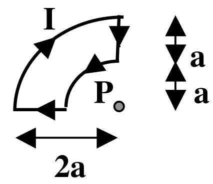
Problem 5

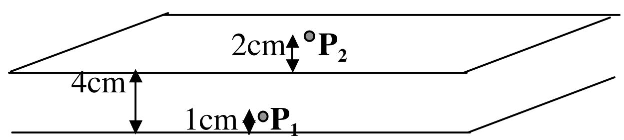


The loop shown is formed of two concentric quarter circles of radii a and 2a, and straight segments of length a, and carries current I in the direction shown. With the convention that the magnetic field at point P at the center of the circles is positive if it points out of the paper and negative if it points into the paper, it is given by B=
(a) $\mu_0 I/8a$; (b) $-\mu_0 I/8a$; (c) $\mu_0 I/16a$; (d) $-\mu_0 I/16a$; (e) $-\mu_0 I/32a$

Problem 6

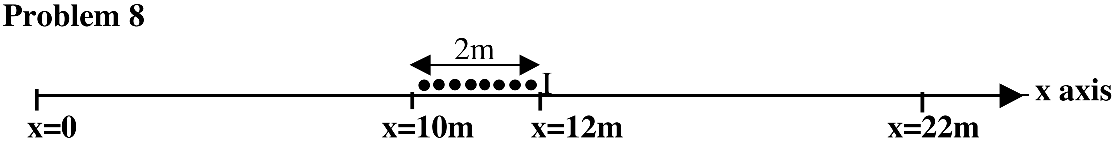
Consider the loop of problem 5, and assume a long straight wire goes through the point P in direction perpendicular to the paper, carrying current I_1 into the paper. The total force exerted on the segment of the loop in the vertical direction (of length a, directly above P) by the magnetic field of the long straight wire, is
(a) $0.1\mu_0 I\, I_1$; (b) $0.2\mu_0 I\, I_1$; (c) $0.3\mu_0 I\, I_1$; (d) $0.4\mu_0 I\, I_1$; (e) $0.5\mu_0 I\, I_1$

Problem 7



The infinite flat sheet of thickness 4cm shown carries a uniform current density in direction perpendicular to the paper (that you're holding). At point P_1 inside the sheet at distance 1cm from the bottom surface the magnetic field has magnitude 2G (G=gauss) and points to the right. At point P_2 which is outside the sheet at distance 2cm above the top surface of the sheet the magnetic field has magnitude ? and points ? (right or left)
(a) 1G, right ; (b) 2G, left ; (c) 4G, left ; (d) 8G, right ; (e) 2G, right

Problem 8



The figure shows 8 long wires pointing perpendicular to the paper each carrying current I in direction out of the paper, distributed over a 2m region, very close and above the x axis. The integral along the x-axis shown $\int_0^{22m} B\,dx = 10^{-5}$ T m. Each wire carries a current I of approximately
(a) 1A ; (b) 2A ; (c) 3A ; (d) 4A ; (e) 5A