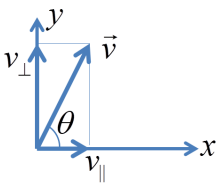
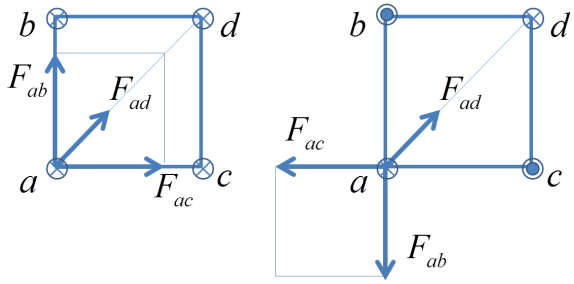
Physics 1214, Homework #4: solutions

Answers to multiple choice questions: M1: C; M2: B; M3: B.

P1: (a) The particle's velocity component along the x axis is $v_{||} = v\cos\theta$, so the time taken by the particle to reach the point $x = 0.5$ cm is $t = \dfrac{x}{v_{||}} = \dfrac{x}{v\cos\theta}$. The particle's velocity component perpendicular to the x axis is $v_\perp = v\sin\theta$, so the time taken by the particle to make a full turn is $t = \dfrac{2\pi R}{v_\perp} = \dfrac{2\pi R}{v\sin\theta}$. From $\dfrac{x}{v\cos\theta} = \dfrac{2\pi R}{v\sin\theta}$ one gets $R = x\dfrac{\tan\theta}{2\pi} = (0.005\text{ m})\dfrac{\sqrt{3}}{2\pi} = 1.38\times10^{-3}$ m. (b) $R = \dfrac{mv_\perp}{|q|B} = \dfrac{mv\sin\theta}{|q|B}$, so $v = \dfrac{R|q|B}{m\sin\theta} = \dfrac{(1.38\times10^{-3}\text{ m})(1.60\times10^{-19}\text{ C})(0.1\text{ T})}{(5.89\times10^{-26}\text{ kg})(\sqrt{3}/2)} = 433$ m/s.



P2: (a) Let's calculate the force acting on wire a (all wires experience the same force due to the symmetry of the construction). Force F_{ab} acting on wire a due to the current in wire b is $F_{ab} = \mu_0\dfrac{I^2L}{2\pi a} = (4\pi\times10^{-7}\text{ N/A}^2)\dfrac{(0.2\text{ A})^2(1\text{ m})}{2\pi(0.01\text{ m})} = 8\times10^{-7}$ N. Similarly, $F_{ac} = \mu_0\dfrac{I^2L}{2\pi a} = F_{ab} = 8\times10^{-7}$ N and $F_{ad} = \mu_0\dfrac{I^2L}{2\pi(\sqrt{2}a)} = \dfrac{1}{\sqrt{2}}F_{ab} = 5.64\times10^{-7}$ N. The resulting force is the vectorial sum of the three forces. It is directed along the square's diagonal, and its magnitude is $F = F_{ab}\left(\sqrt{2}+\dfrac{1}{\sqrt{2}}\right) = F_{ab}\dfrac{3}{\sqrt{2}} = 1.7\times10^{-6}$ N. (b) The calculations are the same except for directions of the forces. The resulting force magnitude is $F = F_{ab}\left(\sqrt{2}-\dfrac{1}{\sqrt{2}}\right) = F_{ab}\dfrac{1}{\sqrt{2}} = 0.57\times10^{-6}$ N.



P3: $\mu_0\dfrac{I_1}{2\pi x} = \mu_0\dfrac{I_2}{2\pi(a-x)}$ $\quad (a-x)I_1 = xI_2$ $\quad x = \dfrac{aI_1}{I_1+I_2} = 2$ cm

Answer: the field is zero at 2 cm from the 0.1 A current and 8 cm from the 0.4 A current.

P4: $N = \dfrac{L}{\pi D} = \dfrac{100\text{ m}}{\pi 0.1\text{ m}} = 318$ $\quad B = \mu_0\dfrac{N}{l}I = 2\times10^{-3}$ T