$[\mu_0 \equiv 4\pi \times 10^{-7}\ T\cdot m/A]$

(1) Four long copper wires are parallel to each other and their perpendicular cross sections form a square 20 cm on edge. A 20 Amp current is set up in each wire in the direction shown in the figure. What are (a) the magnitude and the direction of the magnetic field B at the point P ? (8 + 6 points)

⊙ ≡ I out of page

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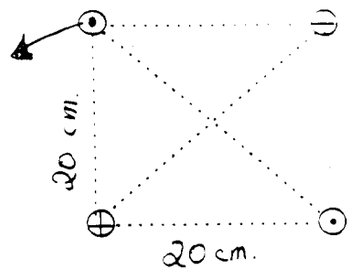
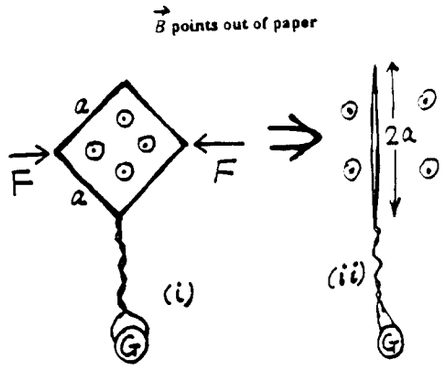


(b) What are the components of the force per unit length (N/m) acting on the wire passing through point P ? (11 points)

(2) A square loop with edge length a=0.4 m is placed with its plane perpendicular to a uniform magnetic field of 4mT. The total resistance of the loop and the wires connecting to a galvanometer is 0.2Ω. The loop is suddenly compressed by two equal and opposite horizontal forces F in 1 ms so that the area enclosed by the loop collapses to zero (see figure).

(a) [8+3+2 points] Calculate the magnitude of the induced *emf* and <u>indicate</u> in the figure its direction with respect to the loop, assuming that the induced *emf* is constant during the 1 ms. What is the induced current?



(b) [5 points] Calculate the total charge that passes through the galvanometer

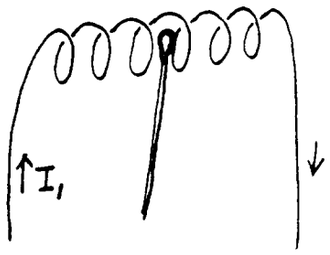
(c) [7 points] Neglect any elastic forces in the loop. Calculate the minimum force F that must be applied to overcome the drag (magnetic) force just before the complete collapse of the loop. (see figure (ii))
[Force=$i\vec{l}\times\vec{B}$]

(3) A solenoid, of radius R_1=3cm and length l_1=50cm , has N_1=150 turns of wire.

(a) [10 pts] What is the inductance L_1 of the solenoid?

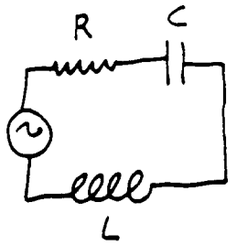
(b) [5 pts] A wire ring of smaller radius R_2=1.5cm is placed near the center of the solenoid (see figure). All the wire turns are coaxial. The mutual inductance M of the solenoid-ring system must be (Pick one of the following answers)

(i) $\mu_0 \pi R_1 R_2$
(ii) $\mu_0 \pi R_2^2$
(iii) $\mu_0 (N_1/l_1) \pi R_1^2$
(iv) $\mu_0 (N_1/l_1) \pi R_2^2$
(v) $\mu_0 (N_1/l_1) \pi R_1 R_2$



(c) [10 pts] A current I_1=2sin(ωt) A at 60Hz is applied to the solenoid. What is the time-dependent induced *emf* in the wire ring?

4. A resistor, **R=900Ω**, a capacitor, **C=0.25μF** and an inductor, **L=2.5 H** are connected in series across a **240 Hz** AC source, with a voltage amplitude of **140 V**. Calculate:



(a)[8 points] The capacitive reactance, X_C, and inductive reactance, X_L

(b)[8 points] The amplitude of the current

(c) [5 points] The phase angle between the current and voltage. Does the current lag or lead the voltage?

(d) [4 points] What frequency would cause $X_C = X_L$?