Homework - chapter 27 [5, 11, 17, 31, 37, 45]
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Q5] a] By right hand rule, top pole must be $\boxed{\text{South Pole}}$ magnetic field must be pointing up.

b] $F_{max} = I\ell B \rightarrow I = \frac{F_{max}}{\ell B} = \frac{(7.50\times10^{-2}N)}{(0.100m)(0.220T)}$

$= 3.4091A \approx \boxed{3.41A}$

c] $F = F_{max}\sin\theta = (7.50\times10^{-2}N)\sin 80.0°$

$= \boxed{7.39\times10^{-2}N}$

Q11]

$$\vec{F} = \int_a^b I d\vec{\ell} \times \vec{B} = I\int_a^b (\hat{i}dx + \hat{j}dy)\times B_0\hat{k}$$

$$= IB_0\int_a^b (-\hat{j}dx + \hat{i}dy) = IB_0(-\Delta x\hat{j} + \Delta y\hat{i})$$

magnitude force depends on points a & b not on the path taken by the wire.

Q17] Right hand rule applied to the velocity & magnitude field which will give the direction of the force.
a] downwards b] inward into the paper c] right

Q31] $F_a = qvB = \frac{mv^2}{r} \rightarrow v = \frac{qrB}{m}$

$$= \frac{(1.60\times10^{-19}C)(6.385\times10^{6}m)(0.50\times10^{-4}T)}{238(1.66\times10^{-27}kg)}$$

$$= \boxed{1.3\times10^{8} m/s}$$

$$\frac{F_B}{F_g} = \frac{qvB}{mg} = \frac{(1.60\times10^{-19}C)(1.3\times10^{8}m/s)(0.50\times10^{-4}T)}{238(1.66\times10^{-27}kg)(9.80m/s^2)}$$

$$= 2.3\times10^{8}$$

$\boxed{\text{Yes}}$, may ignore gravity. magnitude force is more than 200 million times larger than gravity.

37] a] $\tau = NIAB\sin\theta = 12(7.10A)\left[\pi\left(\frac{0.180m}{2}\right)^2\right](5.50\times10^{-5}T)\sin 24°$

$$= \boxed{4.85\times10^{-5} m\cdot N}$$

b] If the coil is free to turn, it will rotate towards the orientation so that the angle is 0. So the $\boxed{\text{north}}$ edge of the coil will rise.

45] $|qE| = (ne)\left(\frac{V}{d}\right) = mg \rightarrow n = \frac{mgd}{eV}$

$$= \frac{(3.3\times10^{-15}kg)(9.80m/s^2)(0.010m)}{(1.60\times10^{-19})(340V)} = 5.94 \approx \boxed{6 \text{ electrons}}$$

✓

Homework- chapter 28 [7,13,19,23,29,35, 41,47]
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Q7] $B_1 = \frac{\mu_0 I}{2\pi r_1} = \frac{(4\pi \times 10^{-7} T \cdot m/A)(35A)}{2\pi(0.060m)} = 1.17 \times 10^{-4} T$

$B_2 = \frac{\mu_0 I}{2\pi r_2} = \frac{(4\pi \times 10^{-7} T \cdot m/A)(35A)}{2\pi(0.100m)} = 7.00 \times 10^{-5} T$

Laws of cosines,

$\theta_1 = \cos^{-1}\left(\frac{(0.060m)^2 + (0.130m)^2 - (0.100m)^2}{2(0.060m)(0.130m)}\right)$

$= 47.7°$

$\theta_2 = \cos^{-1}\left(\frac{(0.100m)^2 + (0.130m)^2 - (0.060m)^2}{2(0.100m)(0.130m)}\right)$

$= 26.3°$

Using magnitudes.

$B_{net\text{-}x} = B_1 \cos(\theta_1) - B_2 \cos\theta_2 = (1.174 \times 10^{-4}T)\cos 47.7°$
$- (7.00 \times 10^{-5}T)\cos 26.3° = 1.626 \times 10^{-5}T$

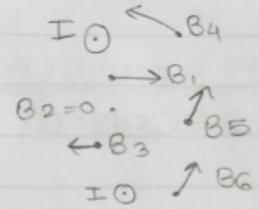
$B_{net\,y} = B_1 \sin(\theta_1) + B_2 \sin\theta_1 = (1.17 \times 10^{-4}T)\sin 47.7°$
$+ (7.00 \times 10^{-5}T)\sin 26.3° = 1.18 \times 10^{-4}T$

$B = \sqrt{B^2_{net\,x} + B^2_{net\,y}} = \sqrt{(1.626 \times 10^{-5}T)^2 + (1.18 \times 10^{-4}T)^2}$
$= 1.19 \times 10^{-4}T$

$\theta = \tan^{-1}\frac{B_{net,y}}{B_{net,y}} = \tan^{-1}\frac{1.18 \times 10^{-4}T}{1.626 \times 10^{-5}T} = 82.2°$

$\vec{B} = 1.19 \times 10^{-4}T$ @ $82.2° \approx \boxed{1.2 \times 10^{-4}T \text{ @ } 82°}$

13] Using right hand rule. magnetic field is inversely proportional to the distance from the wire.



19] $\vec{B}_{net} = \frac{\mu_0 I}{2\pi x}\hat{j} - \frac{\mu_0 I}{2\pi(d-x)}\hat{j} = \boxed{\frac{\mu_0 I}{2\pi}\left(\frac{1}{x} - \frac{1}{d-x}\hat{j}\right)}$

$\boxed{= \frac{\mu_0 I}{2\pi}\left(\frac{d-2x}{x(d-x)}\right)\hat{j}}$

23] a] $dI = \frac{1}{d}dx \quad B_x = \int \frac{\mu_0 \sin\theta}{2\pi r} dI = \frac{\mu_0 I}{2\pi d}\int_{-1/2 d}^{1/2 d} \frac{dx}{\sqrt{x^2+y^2}}$

$\left(\frac{y}{\sqrt{x^2+y^2}}\right) = \frac{\mu_0 I y}{2\pi d}\int_{-1/2 d}^{1/2 d} \frac{dx}{x^2+y^2} = \frac{\mu_0 I y}{2\pi d}\frac{1}{y} \tan^{-1}\frac{x}{y}\Big|_{-d/2}^{d/2}$

$\boxed{\frac{\mu_0 I}{\pi d}\tan^{-1}\left(\frac{d}{2y}\right)}$

b] $\tan^{-1} d/2y \approx d/2y$

$B_x = \frac{\mu_0 I}{\pi d}\tan^{-1}\left(\frac{d}{2y}\right) \approx \frac{\mu_0 I}{\pi d}\frac{d}{2y} = \boxed{\frac{\mu_0 I}{2\pi y}}$

same as magnetic field for field wire.

29] $l = d\frac{L}{\pi(D-d)} = (2.00\times10^{-3} m)\frac{20.0 m}{\pi[2.50\times10^{-2} m - (2.00\times10^{-3} m)]}$

$= \boxed{0.554 m}$

b] $n = \frac{\#\text{turns}}{l} = \frac{\frac{L}{\pi(D-d)}}{l} = \frac{l/d}{l} = \frac{1}{d}$

$B = \mu_0 n I = \frac{\mu_0 I}{d} = \frac{(4\pi \times 10^{-7}\ T \cdot m/A)(16.7A)}{2.00 \times 10^{-3} m}$

$= \boxed{10.5mT}$

35] $\vec{B} = \frac{\mu_0 I_1}{4\pi} \int_{\text{upper}} \frac{ds}{R^2}\hat{k} + \frac{\mu_0 I_2}{4\pi} \int_{\text{lower}} \frac{ds}{R^2}(-\hat{k})$

$= \frac{\mu_0(\pi R)}{4\pi R^2}\hat{k}(I_1 - I_2) = \frac{\mu_0}{4R}\hat{k}(0.35I - 0.65I)$

$= \boxed{\frac{-3\mu_0 I}{40R}}$

41] a] Each infinitesimal current segment dl is parallel to the x axis, as is radial vector. magnitude is proportional to the cross product of the current segment & the radial vector, so $\boxed{\text{zero}}$ field

b] $\vec{B} = \int \frac{\mu_0 I}{4\pi} \frac{d\vec{l} \times \hat{r}}{r^2} = \int \frac{\mu_0 I}{4\pi} \frac{d\vec{l} \times \vec{r}}{r^3} = \frac{\mu_0 I}{4\pi} \int_{-d}^{0}$

$\frac{dx\hat{i} \times (-x\hat{i} + y\hat{j})}{(x^2+y^2)^{3/2}} = \frac{\mu_0 I y}{4\pi}\hat{k} \int_{-d}^{0} \frac{dx}{(x^2+y^2)^{3/2}}$

$= \frac{\mu_0 I y}{4\pi}\hat{k} \left. \frac{x}{y^2(x^2+y^2)^{1/2}} \right|_{-d}^{0} = \boxed{\frac{\mu_0 I}{4\pi y} \frac{d}{(y^2+d^2)^{1/2}}\hat{k}}$

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47] a] $\mu = N\mu_1 = \frac{N_A \rho V}{m_m} \mu_1$

$$= \frac{(6.022 \times 10^{23}\ \text{atoms/mole})(7.80\text{g/cm}^3)(9.0\text{cm})(1.2\text{cm})(1.0\text{cm})}{55.845\text{g/mole}} \left(1.8 \times 10^{-23} \frac{A \cdot m^2}{\text{atom}}\right) = 16.35\ A\,m^2$$

$$\approx \boxed{16 A \cdot m^2}$$

b] $T = \mu B \sin\theta = (16.35 A\,m^2)(0.80T)\sin 90°$

$$= \boxed{13\ m \cdot N}$$

Homework - chapter 29 [5, 11, 19, 29, 33, 39, 47, 51, 55]
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Q5] $\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}(B\pi r^2) = -\frac{dB}{dt}\pi r^2 - 2\pi B r$

$\frac{dr}{dt} = 0$ So, $\frac{dr}{dt} = -\frac{dB}{dt}\frac{r}{2B} = -(-0.010\,T/s)$

$\frac{0.12m}{2(0.500T)} = 0.0012 m/s = \boxed{1.2 mm/s}$

Q11] a] The flux through the loop into the paper is decreasing, as the area is decreasing. So $\boxed{\text{clockwise}}$

b] $|\mathcal{E}_{avg}| = \frac{\Delta\Phi_B}{\Delta t} = \frac{B|\Delta A|}{\Delta t} = \frac{(0.75T)\pi[(0.100m)^2 - (0.030m)^2]}{0.50s}$

$= 4.288 \times 10^{-2} V \approx \boxed{4.3 \times 10^{-2} V}$

c] $I = \frac{\mathcal{E}}{V} = \frac{4.288 \times 10^{-2} V}{2.5\Omega} = \boxed{1.7 \times 10^{-2} A}$

Q19] $\mathcal{E} = -\frac{\Delta\Phi_B}{\Delta t}$, $P = \frac{\mathcal{E}^2}{R}$

$E = P\Delta t = \frac{\mathcal{E}^2}{R}\Delta t = \left(\frac{\Delta\Phi_B}{\Delta t}\right)^2 \frac{\Delta t}{R} = \frac{A^2(\Delta B)^2}{R\Delta T}$

$= \frac{[\pi(0.125m)^2]^2(0.40T)^2}{(150\Omega)(0.12s)} = \boxed{2.1 \times 10^{-5} J}$

29] a] $\mathcal{E} = Blv = (0.35T)(0.250m)(1.3m/s) = 0.1138V \approx \boxed{0.11V}$

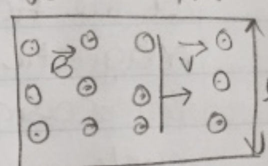
b] $I = \frac{\mathcal{E}}{R} = \frac{0.1138V}{250\Omega + 2.5\Omega} = 4.138 \times 10^{-3}A \approx \boxed{4.1mA}$ using total resistance

c] $F = IlB = (4.138 \times 10^{-3}A)(0.250m)(0.35T)$
$= 3.621 \times 10^{-4}N \approx \boxed{0.36\,mN}$

33] a] without current there is no force to oppose the motion of the rod, so $\boxed{yes}$

b] $F = ma = m\frac{dv}{dt} = -\frac{B^2l^2}{R}v \rightarrow \frac{dv}{v} = -\frac{B^2l^2}{mR}dt$

$\int_0^v \frac{dv'}{v'} = \frac{B^2l^2}{mR}\int_0^t dt' \rightarrow \ln\frac{v}{v_0} = -\frac{B^2l^2}{mR}t \rightarrow$



$\boxed{v(t) = v_0 e^{-\frac{B^2l^2}{mR}t}}$

39] $\sqrt{2}$ and so $V_{rms} = \mathcal{E}_{peak}/\sqrt{2}$
$= NAB\omega/\sqrt{2}$

47] $\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{12000V}{240V} = \boxed{50}$

$\frac{N_S}{N_P} = \frac{V_S}{V_P} \rightarrow \frac{1}{50} = \frac{V_S}{240V} \rightarrow V_S = \frac{1}{50}(240V) = \boxed{4.8V}$

51] a] ohm's law $R_{eq} = \frac{V_0}{I_0} = \boxed{R}$

b] $R = \frac{V_S}{I_S} = \frac{\frac{N_S}{N_P}V_0}{\frac{N_P}{N_P/N_S}I_0} \rightarrow R_{eq} = \frac{V_0}{I_0} = \boxed{\left(\frac{N_P}{N_S}\right)^2 R}$

55] a] Increasing downwards magnetic field creates a circular electric field along the electron path. This field applies an electric force to the electron causing it to accelerate
b] With magnetic field pointing downwards the right hand rule requires the electron travel in $\boxed{\text{clockwise}}$
c] By Lenz's law, the downward magnetic field must be $\boxed{\text{increasing}}$
d] For a sinusoidal wave, field is downwards half of the time & upward. For the half downward its magnitude is decreasing half of the time & other half increasing. Therefore magnetic field is poting downwards & increasing for only one fourth of every cycle.

Homework - chapter 30 [3, 9, 17, 21, 29, 35, 37, 43, 51, 59, 67]

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Q3] $\Phi_{21} = BA_2\sin\theta = \mu_0 \frac{N_1 I_1}{l} A_2 \sin\theta$

$M = \frac{N_2 \Phi_{21}}{I_1} = \frac{n_2 \mu_0 \frac{N_1 I_1}{l} A_2 \sin\theta}{I_1} = \boxed{\frac{\mu_0 N_1 N_2 A_2 \sin\theta}{l}}$

Q9] $V_{ab} = IR + L\frac{dI}{dt} = (3.00A)(3.25\Omega) + (0.44H)(3.60A/s)$
$= \boxed{11.3V}$

Q17] $u_B = \frac{B^2}{2\mu_0} = \frac{1}{2\mu_0}\left(\frac{\mu_0 I}{2R}\right)^2 = \frac{\mu_0 I^2}{8R^2} = \frac{(4\pi\times10^{-7} m/A)(23.0A)^2}{8(0.280m)^2}$

$= \boxed{1.06\times10^{-3} J/m^3}$

Q21] $\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc} \rightarrow B(2\pi r) = \mu_0\left(\frac{I}{\pi R^2}\right)(\pi r^2) \rightarrow B = \frac{\mu_0 I R}{2\pi R^2}$

$\frac{U}{l} = \frac{1}{l}\int u_B dV = \int_0^R \frac{1}{2\mu_0}\left(\frac{\mu_0 I r}{2\pi R^2}\right)^2 2\pi r\, dr$

$= \frac{\mu_0 I^2}{4\pi R^4}\int_0^R r^3 dr = \boxed{\frac{\mu_0 I^2}{16\pi}}$

Q29] $V - I_0 R = 0 \rightarrow I_0 = \frac{V}{R}$

$\mathcal{E} - IR = 0 \rightarrow \mathcal{E} = I_0 R e^{-t/\tau} = Ve^{-tR/L}$
$= (12V)e^{-t(2.2k\Omega)/(18mH)} = \boxed{(12V)e^{-(1.22\times10^5 s^{-1})t}}$

The emf across the inductor is greatest at $\boxed{t=0}$
with a value of $\boxed{\mathcal{E}_{max} = 12V}$

35] a] $\frac{Q^2}{2C} = \frac{1}{2}\frac{Q_0^2}{2C} \rightarrow Q = \boxed{\frac{\sqrt{2}}{2} Q_0}$

b] $\frac{\sqrt{2}}{2} Q_0 = Q_0 \cos \omega t \rightarrow t = \frac{1}{\omega}\cos^{-1}\left(\frac{\sqrt{2}}{2}\right) = \frac{T}{2\pi}$

$\left(\frac{\pi}{4}\right) = \boxed{\frac{T}{8}}$

37] $U = U_E + U_B = \frac{Q^2}{2C} + \frac{LI^2}{2} = \frac{Q_0^2}{2C} e^{-R/Lt} \cos^2(\omega' t + \phi)$

$+ \frac{Q_0^2}{2C} e^{-R/Lt} \sin^2(\omega' t + \phi) = \frac{Q_0^2}{2C} e^{-R/Lt}$

$0.75 \frac{Q_0^2}{2C} = \frac{Q_0^2}{2C} e^{-R/Lt} \rightarrow t = \frac{-L}{R} \ln(0.75) =$

$-\frac{L}{R} \ln(0.75) = \boxed{0.29 \frac{L}{R}}$

43] a] At $\boxed{\omega = 0}$ the impedance of a capacitor is infinite

$\boxed{Z = R + R'}$

b] ~~At~~ $\omega = \infty$, the impedance ~~of~~ capacitor is zero. $\boxed{Z = R'}$

51] $Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (2\pi f L)^2}$

$Z_f = 2Z_{60} \rightarrow \sqrt{R^2 + 4\pi^2 f^2 L^2} = 2\sqrt{R^2 + 4\pi^2 (60\,Hz)^2 L^2} \rightarrow$

$R^2 + 4\pi^2 f^2 L^2 = 4[R^2 + 4\pi^2 (60\,Hz)^2 L^2]$

$= 4R^2 + 16\pi^2 (60\,Hz)^2 L^2 \rightarrow$

$f = \sqrt{\frac{3R^2 + 16\pi^2 (60\,Hz)^2 L^2}{4\pi^2 L^2}} = \sqrt{\frac{3R^2}{4\pi^2 L^2} + 4(60\,Hz)^2}$

$= \sqrt{\frac{3(2500\,\Omega)^2}{4\pi^2 (0.42\,H)^2} + 4(60\,Hz)^2}$

$= 1645\,Hz \approx \boxed{1.6\,kHz}$

59] $P = IV = (I_o \sin\omega t) V_o \sin(\omega t + \phi)$

$= I_o V_o \sin\omega t (\sin\omega t \cos\phi + \sin\phi \cos\omega t)$

$= I_o V_o (\sin^2 \omega t \cos\phi + \sin\omega t \cos\omega t \sin\phi)$

$$\overline{P} = \frac{1}{T}\int_0^T P\,dT = \frac{\omega}{2\pi}\int_0^{2\pi/\omega} I_o V_o (\sin^2\omega t \cos\phi + \sin\omega t \cos\omega t \sin\phi)\,dt$$

$$= \frac{\omega}{2\pi} I_o V_o \cos\phi \int_0^{2\pi/\omega} \sin^2 \omega t\,dt + \frac{\omega}{2\pi} I_o V_o \sin\phi \int_0^{2\pi/\omega} \sin\omega t \cos\omega t\,dt$$

$$= \frac{\omega}{2\pi} I_o V_o \cos\phi \left(\frac{1}{2}\frac{2\pi}{\omega}\right) + \frac{\omega}{2\pi} I_o V_o \sin\phi \left(\frac{1}{\omega} \sin^2\omega t \Big|_0^{2\pi/\omega}\right)$$

$$= \boxed{\frac{1}{2} I_o V_o \cos\phi}$$

67] a] $\overline{P} = I_{rms} V_{rms} \cos\phi = \frac{V_{rms}}{Z} V_{rms} \frac{R}{Z} = \frac{V_{rms}^2 R}{Z^2}$

$$= \boxed{\frac{V_o^2 R}{2[R^2 + (\omega L - 1/\omega C^2)]}}$$

b] $\boxed{f = \frac{1}{2\pi\sqrt{LC}}}$

c] $\overline{P} = \frac{1}{2}\overline{P}_{max} = \frac{V^2 R}{2[R^2 + (\omega L - 1/\omega C)^2} = \frac{1}{2}\left(\frac{V_o^2 R}{2R^2}\right)$

$(\omega L - 1/\omega C) = \pm R \rightarrow 0 = \omega^2 LC \pm RC\omega - 1$

$$\rightarrow \omega = \frac{\pm RC \pm \sqrt{R^2C^2 + 4LC}}{2LC}$$

$$\omega = \frac{2\sqrt{LC} \pm RC}{2LC} = \frac{1}{\sqrt{LC}} \pm \frac{R}{2L} \longrightarrow$$

$$\Delta\omega = \left(\frac{1}{\sqrt{LC}} + \frac{R}{2L}\right) - \left(\frac{1}{\sqrt{LC}} - \frac{R}{2L}\right) = \boxed{\frac{R}{L}}$$

① ✓

Homework - chapter 31 [5, 11, 19, 25, 35, 41]
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Q5] $I_D = \epsilon_0 A \frac{dE}{dt} = \epsilon_0 A \frac{1}{d} \frac{dV}{dt} = \frac{\epsilon_0 A}{d} \frac{dV}{dt} = \boxed{C \frac{dV}{dt}}$

Q11] a] cosine function $kz + \omega t = k(z + ct)$ wave travelling in $\boxed{-z \text{ direction}}$ or $\boxed{-\hat{k}}$

b] $\vec{E}$ and $\vec{B}$ are perpendicular to each other & to the direction of propogation. Since $\vec{E} \times \vec{B}$ must point in the negative z direction, $\vec{B}$ must point in the $\boxed{-y \text{ direction}}$ or $\boxed{-\hat{i}}$. The magnitude of the magnetic field is found as $\boxed{B_0 = E_0/C}$

Q19] a] $\Delta t = \frac{\Delta d}{c} = \frac{(227.9 \times 10^9 m - 149.6 \times 10^9 m)}{(3.000 \times 10^8 m/s)} = \boxed{261s}$

b] $\Delta t = \frac{\Delta d}{c} = \frac{(227.9 \times 10^9 m + 149.6 \times 10^9 m)}{(3.000 \times 10^8 m/s)} = \boxed{1260s}$

Q25] $\bar{S} = \frac{P}{A} = \frac{(1500W)}{[4\pi(5.0m)^2]} = 4.775 W/m^2 \approx \boxed{4.8 W/m^2}$

$\bar{S} = c\epsilon_0 E^2_{rms} \rightarrow E_{rms} = \sqrt{\frac{\bar{S}}{c\epsilon_0}} = \sqrt{\frac{4.775 W/m^2}{(3.00 \times 10^8 m/s)(8.85 \times 10^{-12} C^2/N \cdot m^2)}}$

$= \boxed{42 V/m}$

35] $F_{laser} = PA = \frac{\bar{S}}{c} A = \frac{1}{c}\frac{dU}{dt} = ma = \rho_{H_2O}\pi r^2 r a \rightarrow$

$$a = \frac{dU/dt}{c\rho_{H_2O}\pi r^3} = \frac{(1.0W)}{(3.00\times10^8 m/s)(1000 kg/m^3)\pi(5\times10^{-7}m)^3}$$

$$= \boxed{8\times10^6 m/s^2}$$

41] $f = \frac{1}{2\pi\sqrt{LC}} \longrightarrow L = \frac{1}{4\pi^2 f^2 C}$

$$L_1 = \frac{1}{4\pi^2 f_1^2 C} = \frac{1}{4\pi^2 (88\times10^6 Hz)^2 (620\times10^{-12}F)}$$

$$= 5.3\times10^{-9} H$$

$$L_2 = \frac{1}{4\pi^2 f_2^2 C} = \frac{1}{4\pi^2 (108\times10^6 Hz)^2 (620\times10^{-12}F)}$$

$$= 3.5\times10^{-9} H$$

The range of inductances is $\boxed{3.5\times10^{-9}H \leq L \leq 5.3\times10^{-9}H}$