A. A particle with mass m and positive charge q moves along the circular trajectory of radius R in the x-y plane in the counterclockwise direction in the uniform magnetic field of magnitude B. (i) What is the direction of the magnetic field? (ii) What is the kinetic energy of this particle?

(i) According to the $F = q[V \times B]$ and the right hand rule the magnetic field is in **negative Z** dir.

(ii)

$$\vec{F} = q[\vec{V} \times \vec{B}]$$

$$qVB = m\frac{V^2}{R}$$

$$K = \frac{mV^2}{2} = \frac{q^2}{2m}B^2R^2$$

LO	P	F
3.1		
5.1		
46.1		
46.2		
48.1		

B. A long, straight wire carries a current of I in the direction shown (into the page). An electron is traveling in the vicinity of the wire. At the instant when the electron (charge of electron is $-e$) is distance d from the wire and traveling with a speed of V directly toward the wire, what is the (i) **magnitude** and (ii) **direction** of the force that the magnetic field of the current exerts on the electron?

(i)

$$\vec{F} = -e[\vec{V} \times \vec{B}]$$

$$B = \frac{\mu_o}{2\pi}\frac{I}{d}$$

$$F = eV\frac{\mu_o}{2\pi}\frac{I}{d}$$

(ii) Into the page

LO	P	F
46.3		
46.4		
52.1		

C. Two long, straight, parallel wires are distance ***d*** apart. One wire carries a current I_1. (i) What current is carried by another wire in the same direction if the *force per unit length* exerted by the first wire on the second is ***f*** ? (ii) Is the force between the wires attractive or repulsive?

(i) $d\vec{F}_{12} = I_2 \, d\vec{l} \, \vec{B}_1$

$$B_1 = \frac{\mu_0 I_1}{2\pi d}$$

$$f = \frac{\mu_0 I_1 I_2}{2\pi} \frac{1}{d}$$

$$I_2 = \frac{2\pi f d}{\mu_0 I_1}$$

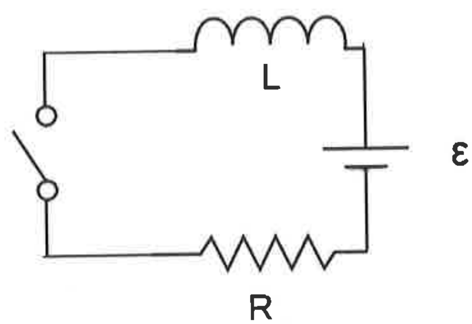
(ii) Applying the rH rule twice produce attractive force

LO	P	F
3.2		
49.1		
52.2		
53.1		
53.2		

D. An RL circuit is connected to a source of emf through a switch. What is the current through the circuit (i) immediately after the switch is closed and (ii) a very long time after the switch is closed?

(i) $I = 0$

(ii) $I = \frac{\varepsilon}{R}$



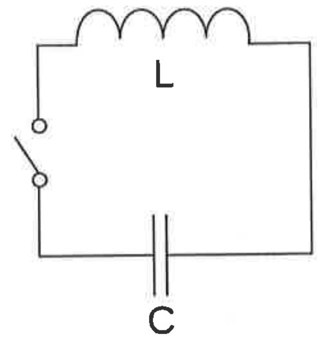
LO	P	F
65.1		
65.2		

Problem I.

An LC circuit consists of an inductor L and a capacitor C. The initial charge of the capacitor is Q_o, and the initial current in the inductor is zero.

A. What is the initial energy stored in the capacitor?

$$U_c = \frac{Q_0^2}{2C}$$



B. What is the maximum current in the inductor?

$$U_{L\,max} = \frac{Q_0^2}{2C} = \frac{1}{2} L I_{max}^2$$

$$I_{max} = \frac{1}{\sqrt{LC}} Q_0$$

C. When the current in the inductor has 1/3 its maximum value, (i) what is the energy stored in the inductor, and (ii) what is the charge on the capacitor?

(i)

$$\frac{1}{18} L I_{max}^2$$

LO	P	F
3.3		
3.4		
5.2		
31.1		
64.1		
66.1		
66.2		

(ii) $$q = \sqrt{Q_0^2 - \frac{1}{9} LC I_{max}^2} =$$

$$= \sqrt{Q_0^2 - \frac{1}{9} LC \frac{1}{LC} Q_0^2} = Q_0 \frac{\sqrt{8}}{3}$$

Problem II.

A long, straight wire with a circular cross section of radius ***R*** carries a current ***I***. Assume that the current density is not constant across the cross section of the wire, but rather varies as $J=\alpha r^2$, where α is a constant and "r" is the distance from the center axis of the wire.

A. By the requirement that J integrated over the cross section of the wire gives the total current ***I***, what is the constant α in terms of ***R*** and ***I***?

$$I = \int J\,dA = 2\pi \int_0^R \alpha r^2\, r\,dr = 2\pi\alpha \frac{1}{4} R^4$$

$$\alpha = \frac{2}{\pi}\frac{I}{R^4}$$

B. What is the magnitude of magnetic field B outside of the wire as a function of distance from the center of the wire (r>***R***)?

$$\oint B\,dl = \mu_0 I \quad ; \quad 2\pi r B = \mu_0 I$$

$$B = \frac{\mu_0}{2\pi}\frac{I}{r}$$

C. What is the magnitude of magnetic field B inside the wire as a function of distance from the center of the wire (r<***R***)?

$$\oint B\,dl = \mu_0 \int_0^{r'} \alpha r^2 2\pi r\, dr$$

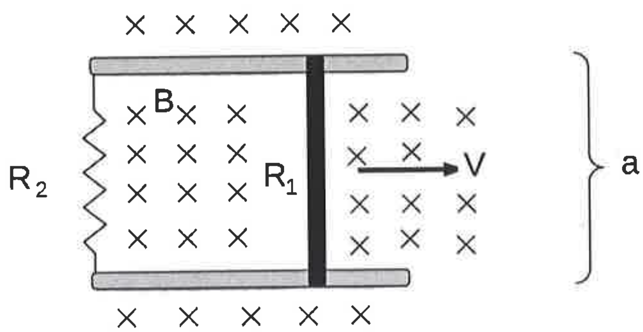
$$2\pi r' B = \mu_0 \frac{2\pi}{4} \alpha r'^4$$

$$B(r') = \frac{\mu_0}{4}\alpha r'^3$$

LO	P	F
3.5		
5.3		
7.1		
7.2		
54.1		
54.2		
55.1		
55.2		

Problem III.

A rod of length ***a*** with resistance R_1 slides without friction on two resistance-free tracks which are connected by a resistor R_2 in a uniform magnetic field ***B*** that is perpendicular to the plane of the tracks.



A. What is the magnitude and direction (clockwise or counterclockwise) of the current through the resistors if the rod has constant velocity in the direction shown in the figure?

direction – using Lenz's law we get counterclockwise

$$\mathcal{E} = -\frac{dBax}{dt} = -BaV$$

$$I = \frac{BaV}{R_1+R_2}$$

B. What force needs to be applied to the rod to maintain constant velocity of the rod?

$$\sum F = \vec{F}_{ap} + \vec{F}_{mag} = 0$$

$$\vec{F}_{mag} = I\vec{a} \times \vec{B}$$

$$F_{ap} = IaB$$

LO	P	F
36.1		
41.1		
49.2		
58.1		
59.1		