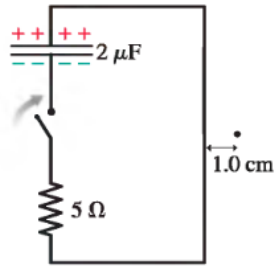
Name _____

PHY2049C, Homework 6

A- Submit a handwritten version of the solutions (clearly readable) at the beginning of class.

Problem 1



The capacitor in the figure is charged to 50 V. The switch closes at t = 0 s. Draw a graph showing the magnetic field strength as a function of time at the position of the dot. On your graph indicate the maximum field strength, and provide an appropriate numerical scale on the horizontal axis.

Problem 2

When a rigid charge distribution with charge Q and mass M rotates about an axis, its magnetic moment $\boldsymbol{\mu}$ is linearly proportional to its angular momentum $\boldsymbol{L}$, with $\boldsymbol{\mu}=\alpha\boldsymbol{L}$. The constant of proportionality α is called the gyromagnetic ratio of the object. We can write $\alpha = g(Q/2M)$, where g is a dimensionless number called the g-factor of the object. Consider a spherical shell with mass M and uniformly distributed charge Q centered on the origin O and rotating about the z-axis with angular speed ω.

(a) A thin slice with latitude θ measured with respect to the positive z-axis describes a current loop with width $Rd\,\theta$ and radius $r = R \sin\theta$ as shown in Figure 1. What is the differential current dI carried by this loop in terms of Q, ω, R, θ and dθ,

(b) The differential magnetic moment contributed by that slice is $d\mu = A\,dI$, where $A = \pi r^2$ is the area enclosed by the loop. Express the differential magnetic moment in terms of Q, ω, R, θ and dθ
What is the differential current dI

(c) Integrate over θ to determine the magnetic moment $\boldsymbol{\mu}$

(d) what is the magnitude of the angular momemtum **L?**

(e) Determine the gyromagnetic ratio α.

(f) What is the g-factor for a spherical shell?

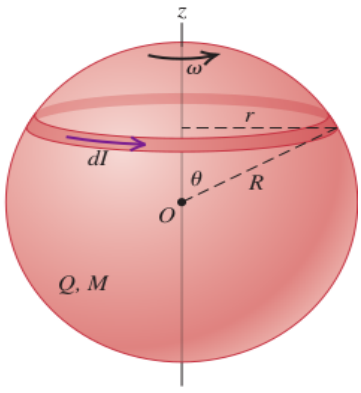


Figure 1

Problem 3

A cylindrical shell with radius R and length W carries a uniform charge Q and rotates about its axis with angular speed ω. The center of the cylinder lies at the origin *O* and its axis is coincident with the x-axis, as shown the Figure below

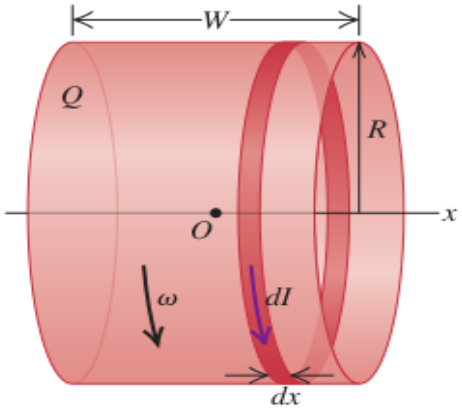
(a) What is the charge density σ?

(b) What is the differential current dI on a circular strip of the cylinder centered at *x* and with width *dx*?

(c) Use Eq. (12.16) (see below) to write an expression for the differential magnetic field dB at the origin due to this strip. Note that on the figure, the coordinate x corresponds to the coordinate y in the equation.

$$\vec{\mathbf{B}} = \frac{\mu_0 \mu \hat{\mathbf{j}}}{2\pi(y^2 + R^2)^{3/2}}.$$

(d) Integrate to determine the magnetic field at the origin.



Problem 4

A rectangular loop of length *l* and width w is located a distance *a* from a long, straight wire, as shown in Figure 2. What is the mutual inductance of this arrangement?

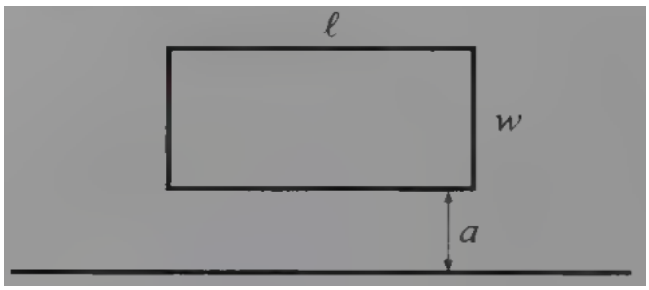


Figure 2

Problem 5 (Wolfson and Passachof)

A wire of length *l* and resistance R is formed into a closed rectangular loop twice as long as it is wide. It is mounted on a nonconducting horizontal axle parallel to its longer dimension, as shown in Figure 3. A uniform magnetic field **B** points into the page, as shown. A long string of negligible mass is wrapped many times around a drum of radius *a* attached to the axle, and a mass m is attached to the string. When the mass is released it falls and eventually reaches a speed that, averaged over one cycle of the loop's rotation, is constant from one rotation to the next. Find an expression for that average terminal speed.