

1. (10%) A ball of mass m is suspended by a massless string of length L . It travels in a horizontal circle of radius r at a constant speed v , while the string makes an angle θ with respect to the vertical axis, as shown in Fig. 1. Find the speed of the ball, and the tension in the string, in terms of the other parameters.

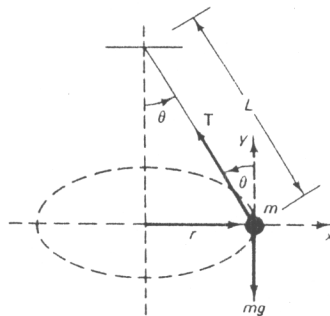


Fig. 1

2. (10%) A solid conducting sphere of radius r_1 has a charge $+Q$. It is surrounded by a concentric hollow conducting sphere of inside radius r_2 and outside radius r_3 . Use Gauss' theorem to get expressions for:
- The field outside the outer sphere.
 - The field between the spheres.
3. (15%) A resonant circuit consists of a parallel plate capacitor (C) and an inductor of N turns wound on a toroid. All linear dimensions of the capacitor and inductor are reduced by a factor 10, while the number of turns on the toroid remain constant.
- By what factor the capacitance changed. Why?
 - By what factor the inductance changed. Why?
 - By what factor the resonant frequency of the resonant circuit changed. Why?
4. (10%) Find the energy of a 7,000 Å photon. ($h=6.626 \times 10^{-34} \text{ J} \cdot \text{s}$)
5. (10%) A uniform magnetic field B , with magnitude 1.2 mT, is directed vertically upward through the volume of a laboratory chamber. A proton with speed $3.2 \times 10^7 \text{ m/s}$ enters the chamber, moving horizontally from south to north. What magnetic deflecting force acts on the proton as it enters the chamber? The proton mass is $1.67 \times 10^{-27} \text{ kg}$. (Neglect Earth's magnetic field.)

6. (15%) What is the Pauli exclusion principle? Explain the role of the Pauli exclusion principle in describing the electrical properties of metals.
7. (9%) A cylinder of mass 1 kg rolls without slipping on a rough surface. At the instant its center of mass has a speed of 1 m/s, determine (a) the translational kinetic energy of its center of mass, (b) the rotational kinetic energy about its center of mass, and (c) its total kinetic energy.
8. (9%) A 1-kg mass is attached to a spring and placed on a horizontal smooth surface. A horizontal force of 10 N is required to hold the mass at rest when it is pulled 0.1 m from its equilibrium position (the origin of the x axis). The mass is now released from rest with an initial displacement of $x_0=0.1\text{m}$, and it subsequently undergoes simple harmonic oscillations. Find (a) the force constant k of the spring, (b) the frequency f of the oscillations, and (c) the maximum speed v_{max} of the mass.
9. (12%) What is the photoelectric effect? Explain.