

1. The external force needed to produce an extension  $x$  in a string is given by  $F(x) = 8x + x^3$  N. What is the work needed to extend it from  $x = 1$  m to  $x = 2$  m ? ( 10 % )
2. A uniform rod of mass  $m$  and length  $L$  is freely pivoted at one end. What is the period of its oscillation ? ( 10 % )
3. An ideal gas expands adiabatically to twice its original volume and in the process it does 400 J of work. ( 8 % ) (a) What is the change in its internal energy ? ( 7 % ) (b) What is the heat transfer ?
4. A wave on a string is given by  $y = 3 \sin(2x + 10t)$ , where  $x$  and  $y$  are in meters and  $t$  is in seconds. Find ( 8 % ) (a) the wavelength and period, ( 7 % ) (b) the particle velocity at  $x = 2$  m and  $t = 0.2$  s.
5. An insulating solid sphere of radius  $R$  has a uniform positive volume charge density and total charge  $Q$ .
  - (a) Find the electric potential at a point outside the sphere, that is, for  $r > R$ . Take the potential to be zero at  $r = \infty$ . (5%)
  - (b) Find the potential at a point inside the sphere, that is, for  $r < R$ . (5%)
6. A long solenoid of radius  $R$  has  $n$  turns of wire per unit length and carries a time-varying current that varies sinusoidally as  $I = I_{\max} \cos(\omega t)$ , where  $I_{\max}$  is the maximum current and  $\omega$  is the angular frequency of the alternating current source.
  - (a) Determine the magnitude of the induced electric field outside the solenoid at a distance  $r > R$  from its long central axis. (5%)
  - (b) What is the magnitude of the induced electric field inside the solenoid, a distance  $r$  from its axis ? (5%)
7. Monochromatic light from a helium-neon laser ( $\lambda = 632.8$  nm) is incident normally on a diffraction grating containing 6000 grooves per centimeter. Find the angles at which the first- and second-order maxima are observed. (10%)
8. Briefly describe (a) The Hall effect, (b) Displacement current, (c) Meissner effect, (d) Coherent waves, and (e) Polarization of light waves by reflection. (20%)