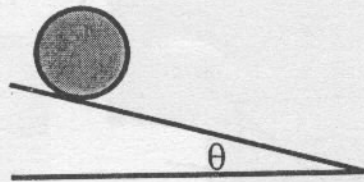


1. (a) The position  $y$  of a particle moving along the  $y$  axis depends on the time  $t$  according to the equation  $y = at - bt^2$ . Find the dimensions (單位) of the quantities  $a$  and  $b$ .  
 (b) Plot a graph which represents the motion of an object moving with a constant speed. The  $x$ -axis is the time and the  $y$ -axis is the displacement (位移). (10%)

2. (a) A system of  $n$  moles of ideal gas undergoes an isothermal process at temperature  $T$ . The initial and final volume of the system is  $V_i$  and  $V_f$ , respectively. Find the work done by this process. In your answer, you may need to use the ideal gas constant  $R$ .  
 (b) Consider a system of  $n$  moles of ideal gas follows a free expansion process which takes the system from an initial state to a final state where the volume of the system is doubled, i.e.,  $V_f = 2V_i$ . Find the entropy change of this system.  $R$  is the ideal gas constant. (10%)

3. A solid disk of radius  $r$  and mass  $m$  rolls down a slope from rest, as shown in the figure. (10%)

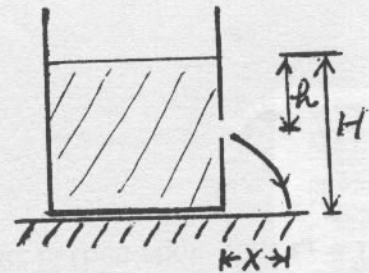


Let the angle of the slope be  $\theta$ . Find

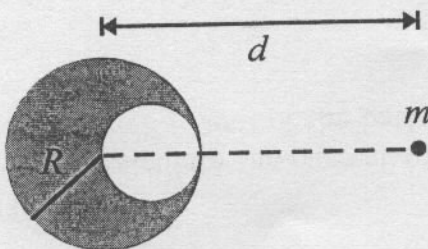
- (a) (3 points) the linear acceleration of the rolling disk;  
 (b) (3 points) the frictional force between the disk and the slope;  
 (c) (4 points) the speed of the disk at the bottom of the slope if the disk travels a distance  $L$  to reach the bottom of the slope.

4. A tank is filled with water to a height  $H$ . A hole is punched in one of the walls at a depth  $h$  below the water surface, as shown in the figure right: (10%)

- (a) (3 points) Evaluate  $x$ , the distance from the base of the tank to the point at which the resulting stream strikes the floor.  
 (b) (3 points) Could a hole be punched at another depth which would give the same range?  
 (c) (4 points) At what depth should the hole be punched to maximize the range?

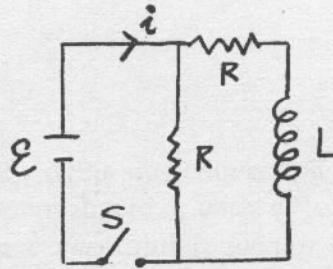


5. A spherical hollow is made in a lead sphere of radius  $R$ , such that its surface touches the outside surface of the lead sphere and passes through its center. The mass of the sphere before hollowing was  $M$ . With what force, according to the law of universal gravitation, will the hollowed lead sphere attract a small sphere of mass  $m$ , which lies a distance  $d$  from the center of the lead sphere on the straight line connecting the centers of the spheres and of the hollow? (10%)



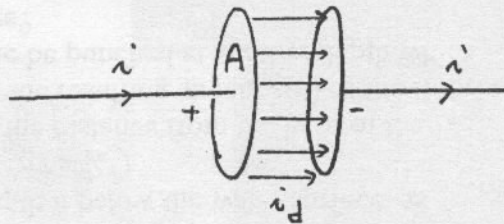
6. (10%)

Please calculate the current  $i$  through the battery (a) just after  $S$  is closed (b) a long time later. [where  $\mathcal{E}$  = emf of the battery,  $L$  = inductor,  $R$  = resistor, and  $S$  = switch]



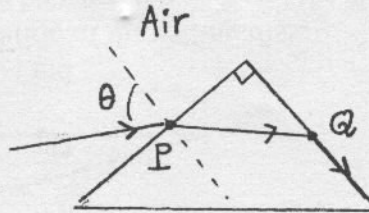
7. (10%)

For a charging circular plates with area  $A$  (neglecting the edge effect), the external current  $i$  that is charging the plates changes the electric field  $\mathbf{E}$  between the plates. If, between the plates,  $i_d$  is the displacement current associated with that changing field  $\mathbf{E}$  then show that  $i_d = i$ .



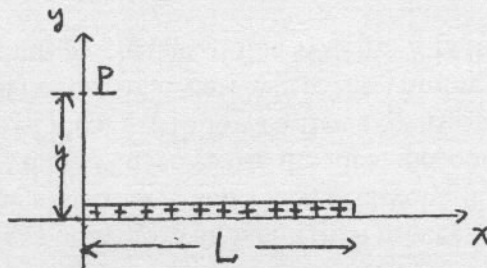
8. (10%)

If a light enters a  $90^\circ$  triangular prism at point  $P$  with incident angle  $\theta$  and then some of it refracts at point  $Q$  with an angle of reflection of  $90^\circ$ . (a) What is the index of reflection of the prism in terms of  $\theta$ ? (b) What, numerically, is the maximum value that the index of refraction can have?



9. (10%)

The plastic rod of length  $L$  has the non-uniform linear charge density  $\lambda = cx$ , where  $c$  is a positive constant. (a) With  $V = 0$  at infinity, find the electric potential at point  $P$  on the  $y$  axis. (b) Find the electric field component  $E_y$  at  $P$ .



10. (10%)

An electron with mass  $m$  is confined to an (one-dimensional) infinitely deep potential energy well of width  $L$ . (a) What is the normalized wave functions  $\psi_n(x)$ ? (b) What is the quantized energies  $E_n$ ?

