類組：物理類　科目：普通物理(2002)　　共 2 頁 第 1 頁

※請在答案卷內作答

一、 (20%) In Fig 1, the geometry of a nonconducting material is composed of a sphere of radius $2a$ centered at the origin and a spherical cavity of radius $a$ centered at $y = a$ on the $y$ axis. The material has a uniform positive charge density $\rho$ that is not affected by the electric field. Find the magnitude and direction of the electric field **E** at (a) (5%) $y = 3a$, (b) (5%) $y = 0$, and (c) (10%) $y = -a$ on the $y$ axis.

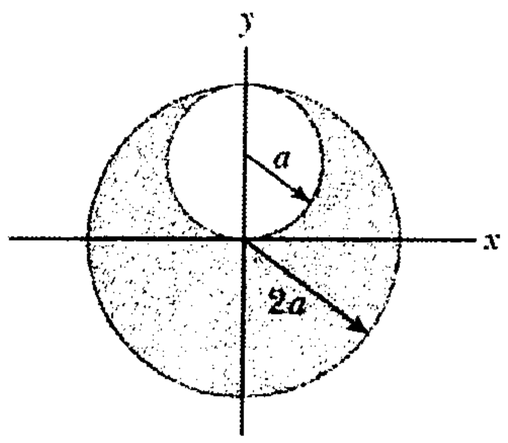


Fig. 1

二、 (10%) In Fig. 2, the switch is open for $t < 0$ and then closed at time $t = 0$. (a) (5%) What is the current passing through the switch right after the initial (at $t = 0^+$)? (b) (5%) What is the current passing through the resistor $2R$ in the long time limit?

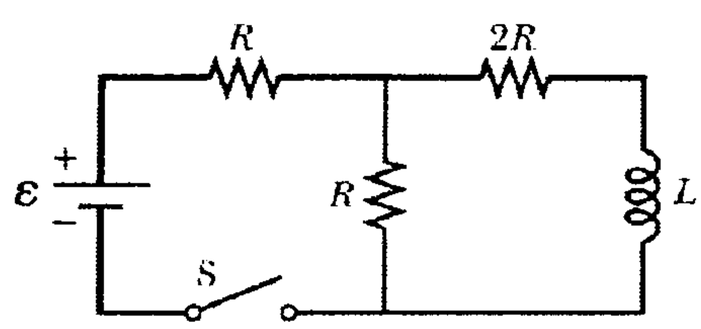


Fig. 2

三、 (20%) In Fig. 3, a long, cylindrical conductor of radius $R$ carries a current density

$$J(r) = \frac{3I}{\pi R^2}\left(1-(r/R)\right),$$

where $r$ is the distance from the central axis of the conductor and $I$ is the total current. (a) (5%) Find the magnetic field ***B*** at distance $r > R$. (b) (5%) Find ***B*** at distance $r < R$. (c) (10%) Where is the maximum of $B$ and what is the maximum?

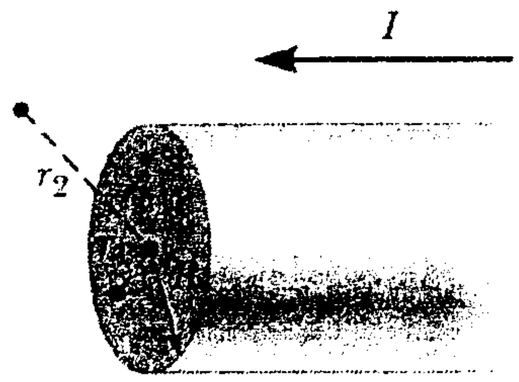


Fig. 3



注意：背面有試題

四、 (15%) A car of mass $m$ and speed $v$ runs on a road and negotiates a curve of radius $r$ under the gravitational acceleration $g$. The roadway is tilted toward the inside of the curve and has a banked angle $\theta$. The coefficient of static friction between the tires and the road is $u_s$. To make the turn successfully, (a) (4%) what is the minimum $u_s$, if $\theta = 0$? (b) (4%) what is $\theta$, if $u_s = 0$? (c) (7%) what is the minimum and maximum $\theta$, if $u_s > 0$?

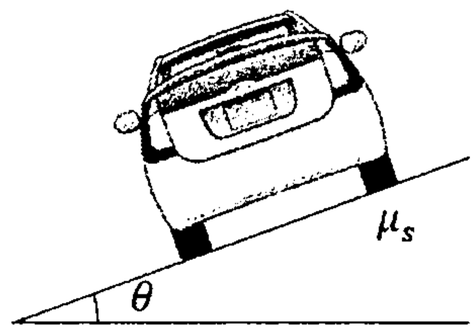


Fig. 4

五、 (15%) A disk of mass $m$ is connected by a string passing through a small hole in a table. If the string is pulled by a hand, the disk undergoes a frictionless circular motion of radius $R$ and speed $v$. (a) (5%) What is the speed of the disk, when the radius is decreased to $r$? (b) (5%) How much work is done by the hand in this process? (c) (5%) If the hand is replaced by a cylinder of mass $M$ under the gravitational acceleration $g$, the circle radius will increase to $2r$. How large is $M$?

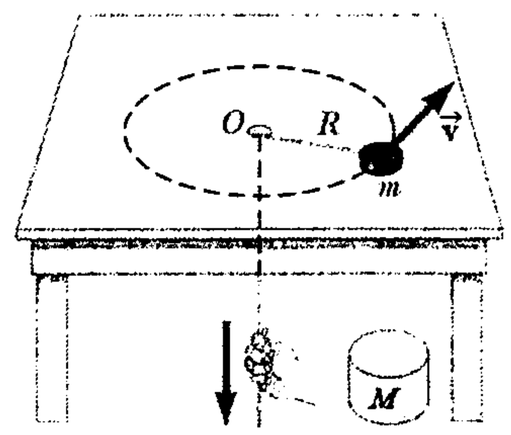


Fig. 5

六、 (10%) A tuning fork oscillating at frequency $f$ is put on a car moving at a constant speed of $v_c$ toward a wall. The speed of sound in air is $v$. (a) (5%) What is the beat frequency between the tuning fork and its echo? (b) (5%) How fast must the car run away from the wall to observe a beat frequency $f_b$?

七、 (10%) Consider a cylindrical rod of radius $r$ floating upright in a fluid of density $\rho$ under the gravitational acceleration $g$. When the rod is pushed down a distance $x$ from its equilibrium position and released, it undergoes a frictionless oscillation on the fluid surface. (a) (5%) What is the period of that oscillation? (b) (5%) Should one make $x$ small to obtain a simple harmonic motion for this oscillation and why?