1.(a) (15%) As shown in the figure (a) below, there is an uniform charge distribution with density ρ in the region bounded by the infinite planes at $x = -a$, and $x = a$. Apply Gauss's Law to determine the direction and the magnitude of the ***E***-field for positions on the ***x***-axis.

(b) (10%) Figure (b) below shows the case that the charges in the cylindrical region with radius $b = a/2$ in the charge distribution in part (a) is removed, determine the direction and the magnitude of the ***E***-field at point ***P*** (2***a***, 2***a***, 0).

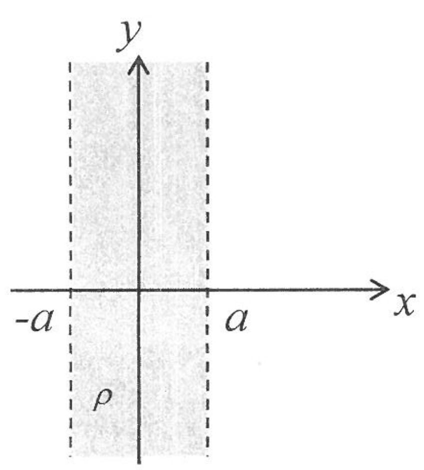


Figure (a)

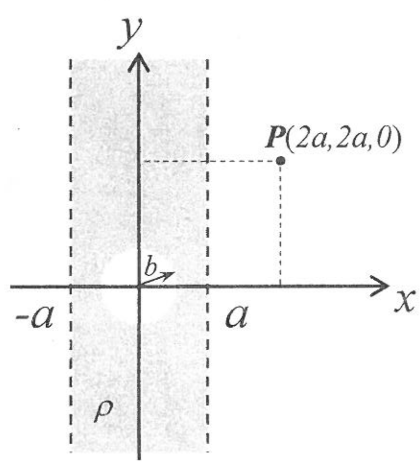


Figure (b)

2.(a) (15%) As shown in the figure (c) below, there is an uniform current desnity distribution in the cylindrical region with radius ***a***, and with current density ***J*** in the +*z*-direction (i.e out-of-page). Apply Ampere's Law to determine the direction and the magnitude of the ***B***-field for positions on the ***y***-axis.

(b) (10%) Now assume that the current density is a function of the distance ***r*** from the origin , i.e. $J(r) = J_0 \cdot r$, determine the direction an the magnitude of the ***B***-field at point ***P*** (2***a***, 2***a***, 0).

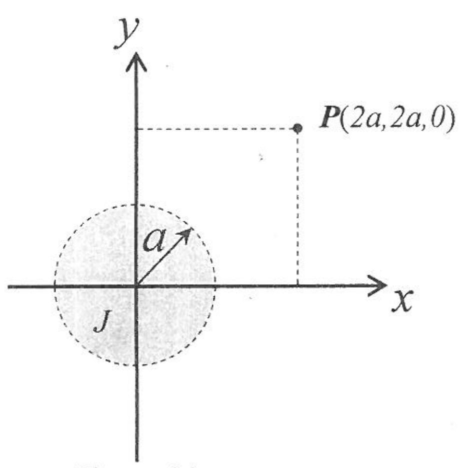


Figure (c)

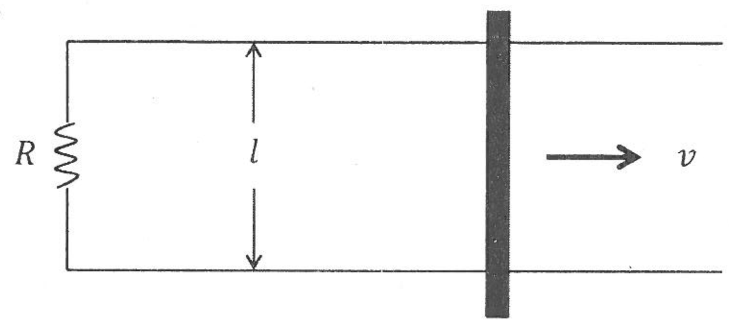
3. A metal bar of mass m slides frictionlessly on two parallel conducting rails a distance l apart (see figure in below). A resistor R is connected across the rails and a uniform magnetic field **B**, pointing into the page, fill the entire region.

(a) If the bar moves to the right at speed v, what is the current in the resistor? (3%) In what direction does it flow? (2%)

(b) What is the magnetic force on the bar? (3%) In what direction? (2%)

(c) If the bar starts out with speed v_0 at time $t = 0$, and is left to slide, what is its speed at a later time t? (5%)

(d) The initial kinetic energy of the bar is $\frac{1}{2}mv_0^2$. When the bar stops, its kinetic energy becomes zero. Where does the kinetic energy go? (2%) Prove that energy is conserved in this process by showing that the energy gained elsewhere is exactly $\frac{1}{2}mv_0^2$. (3%)



4. Write down the electric and magnetic fields for a monochromatic plane wave of amplitude E_0, frequency ω, and phase angle zero that is

(a) travelling in the negative x-direction and polarized in the z-direction; (6%)

(b) travelling in the direction from the origin toward the point (1, 1, 1), with polarization parallel to the x-z plane. (6%)

(c) In each case, sketch the wave and give the explicit Cartesian components of $\boldsymbol{\kappa}$ and $\hat{\boldsymbol{n}}$, where κ and $\hat{\boldsymbol{n}}$ are wave vector and polarization unit vector. (8%)

5. Write down Maxwell's equations in differential form and describe the physical meaning of each equation. (10%)