25. (II) A conducting rod rests on two long frictionless parallel rails in a magnetic field **B** (⊥ to the rails and rod) as in Fig. 29–35. (*a*) If the rails are horizontal and the rod is given an initial push, will the rod travel at constant speed even though a magnetic field is present? (*b*) Suppose at $t = 0$, when the rod has speed $v = v_0$, the two rails are connected electrically by a wire from point a to point b. Assuming the rod has resistance R and the rails have negligible resistance, determine the speed of the rod as a function of time. Discuss your answer.

26. (III) Suppose a conducting rod (mass m, resistance R) rests on two frictionless and resistanceless parallel rails a distance l apart in a uniform magnetic field **B** (⊥ to the rails and the rod) as in Fig. 29–35. At $t = 0$, the rod is at rest and a source of emf is connected to the points a and b. Determine the speed of the rod as a function of time (*a*) if the source puts out a constant current I, (*b*) the source puts out a constant emf $\mathscr{E}_0$. (*c*) Does the rod reach a terminal speed in either case? If so, what is it?

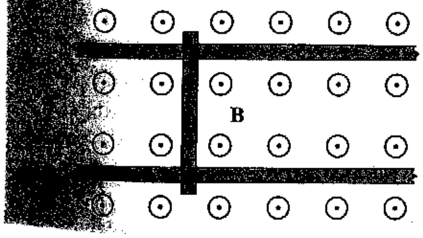
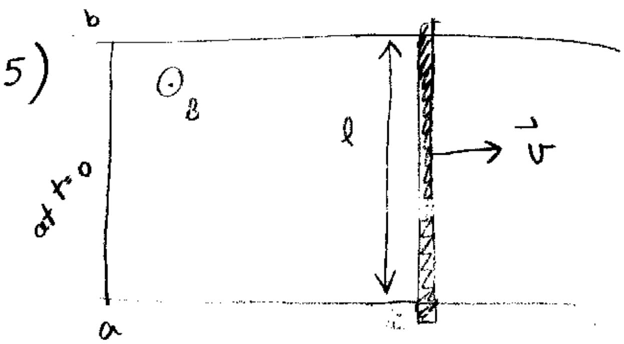


FIGURE 29–35 Problems 25 and 26.

25)



a) The circuit is open

$\Rightarrow$ no I_{ind}

$\Rightarrow$ moves at const v

b) Now a current is induced.

$A = A(t)$

$$|\mathcal{E}| = \left|\frac{d\Phi}{dt}\right| = \left|\frac{d}{dt}(B \cdot A)\right|$$

$$= B\frac{dA}{dt}$$

$A = l \cdot x$

$\frac{dA}{dt} = l\frac{dx}{dt} = lv$

$$= Blv$$

$$\Rightarrow I = \frac{\mathcal{E}}{R} = \frac{Blv}{R}$$

By Lenz Rule, current opposes change... opposes increase of B in ⊙ dir $\Rightarrow$ creates B in ⊗ dir $\Rightarrow$ CW

Force on rod due to current in it:

$$F = -IBl = -\frac{B^2 l^2 v}{R} = ma$$

$$-\frac{B^2 l^2 v}{R} = m\frac{dv}{dt} \quad \Big\} \text{ a DE for } v(t)$$

$$\int_{v_0}^{v} \frac{dv}{v} = -\int_0^t \frac{B^2 l^2}{mR}\, dt$$

$$\ln\frac{v}{v_0} = -\frac{B^2 l^2}{mR} t$$

$$\Rightarrow \boxed{v = v_0 e^{-B^2 l^2 t/mR}}$$

Eventually slows down & stops.