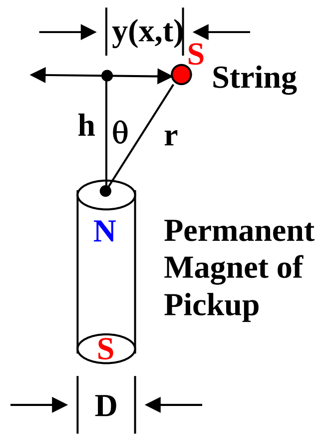

Thus, the separation distance, r between vibrating string and permanent magnetic pole of a guitar pickup on an electric guitar varies with time, as

$$r(t) = y(x,t)/\sin\theta$$

However, the typical magnitude of transverse displacement, y(x,t) from the equilibrium position of the string is $|y_o| \sim$ 1-2 mm, whereas the typical diameter of the permanent magnets used in electric guitar pickups is D ~ 4-5 mm. Thus, the string vibrates mostly over the pole of the pickup, a distance z = h above it, where the magnetic field, B(z=h) from the pole of the permanent magnet is fairly constant with transverse amplitude, as long as |y(x,t)| < D.

The attractive force between the magnetically permeable string and the pole of the permanent magnet is given (approximately) by:

$$F_{mag}(r) \cong -\frac{(2r_{string}D)}{2\mu_o}B^2(r) = -\frac{r_{string}D}{\mu_o}B^2(r)$$

where $2r_{string}D \cong$ area of magnetized string over the magnetic pole of the electric guitar pickup, μ_o = magnetic permeability of free space = $4\pi\times10^{-7}$ Henry/meter. This attractive magnetic force, for "horizontal" transverse vibrations (i.e. parallel to the plane of the strings of the electric guitar), will be approximately constant with separation distance, r if the equilibrium position of each of the strings is well-aligned with the corresponding magnetic pole of the pickup - sometimes this is not the case! If there is a misalignment of a string and its corresponding magnetic pole on the pickup, then B(r) will not be ~ constant, and hence $F_{mag}(r)$ will vary with the horizontal transverse vibrations of the string. Since the "fringe" portion of the magnetic field of a dipole magnet varies as $B(r) \sim 1/r^3$, then the magnetic force in this situation will vary as $F_{mag}(r) \sim 1/r^6$!

When the plane of polarization of the transverse vibration of a string on an electric guitar is vertical - i.e. perpendicular to the plane of the strings, then B(r) also varies significantly (since the string vibrations are now parallel to the axis of the permanent magnet), and hence so does $F_{mag}(r)$.