[mex145] Close encounter of the first kind

A rock of mass $m$ approaches the solar system with a velocity $v_0$, and if it had not been attracted toward the sun it would have missed the sun by a distance $d$. Neglect the influence of the planets. Show that the closest approach of the orbit is

$$a = \sqrt{d^2 + d_0^2} - d_0, \quad d_0 = \frac{Gm}{v_0^2}.$$ 

Solution: