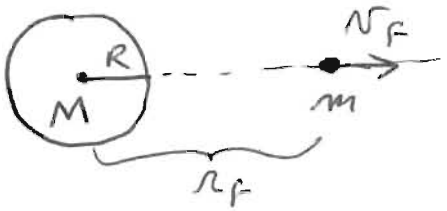
5. (25 pts.) The asteroid Toro has a radius of 5×10^3 m and a mass of 2.0×10^{15} kg. Suppose that an astronaut throws a rock of mass 3 kg straight up from the surface of the asteroid with an initial speed of 18 m/s. What is the speed of the rock when it is 2×10^4 m above the center of the asteroid? (Neglect the gravitational forces due to all other objects.)

5. (25 pts.) The asteroid Toro has a radius of 5×10^3 m and a mass of 2.0×10^{15} kg. Suppose that an astronaut throws a rock of mass 3 kg straight up from the surface of the asteroid with an initial speed of 18 m/s. What is the speed of the rock when it is 2×10^4 m above the center of the asteroid? (Neglect the gravitational forces due to all other objects.)

initial

final



$M = 2 \times 10^{15}$ kg

$r_i = R = 5 \times 10^3$ m

$v_i = 18$ m/s

$r_f = 2 \times 10^4$ m

$v_f = ?$

$$E_i = E_f$$

$$U_i + K_i = U_f + K_f$$

$$-\frac{GMm}{R} + \frac{1}{2}mv_i^2 = -\frac{GMm}{r_f} + \frac{1}{2}mv_f^2$$

$$v_f^2 = \frac{2GM}{r_f} - \frac{2GM}{R} + v_i^2 = 2GM\left(\frac{1}{r_f} - \frac{1}{R}\right) + v_i^2$$

$$v_f^2 = 2(6.67 \times 10^{-11})(2 \times 10^{15})\left(\frac{1}{2 \times 10^4} - \frac{1}{5 \times 10^3}\right) + (18)^2$$

$$v_f^2 = 285.\ m^2/s^2$$

$$\boxed{v_f = 16.9 \text{ m/s}}$$