Thurs: Discussion/quiz

Ex 339, 341, 342, 344, 347, 349

Fri: Review for Final

Final covers: ENTIRE SEMESTER

Section 001 (10am) Mon, May 15, 10am - 11:50am

Section 002 (11 am) Weds, May 17, 10 am - 11:50am

Gravitational Potential Energy

Consider a (space) ball that falls toward the Earth. Then Newton's Second Law gives.

$$\vec{F}_{net} = m\vec{a} \Rightarrow G\frac{mM}{r^2} = ma \Rightarrow a = G\frac{M}{r^2}$$

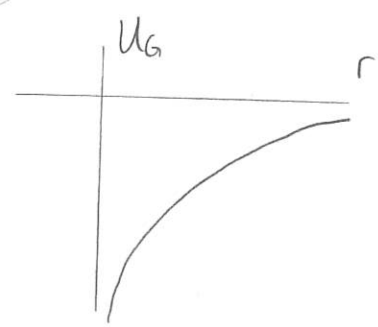
As the object falls acceleration increases. So we cannot use constant acceleration kinematics to analyze the motion. We can use energy. This results from

Work done by gravity satisfies

$$W_G = -\Delta U_G$$

where the gravitational potential energy is

$$U_G = -G\frac{Mm}{r}$$



Quiz 1 10% — 80% ⦚ 30% — 30%

Warm Up 1 As $r \to \infty$ $\left.\begin{array}{l} U_G \to 0 \\ K \to 0 \end{array}\right\} \Rightarrow E \to 0$

So $E = 0$

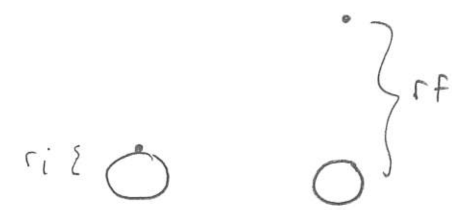
348 Ball launch on Phobos

Phobos, a moon of Mars has mass 1.06×10^{16} kg and mean radius 11.3×10^{3} m. A ball is launched vertically from the surface of Phobos. *(131Sp2023)*

a) Suppose that the ball is launched with speed 8.00 m/s. Determine the maximum distance, from the center of Phobos, that it reaches.

b) Determine the minimum speed with which the ball must be launched to escape Phobos.

Answer: Both cases $\quad E_f = E_i$



$$K_f + U_{gf} = K_i + U_{gi}$$

$$\cancel{\tfrac{1}{2} m v_f^2} - G\frac{\cancel{m}M}{r_f} = \frac{1}{2}\cancel{m} v_i^2 - G\frac{\cancel{m}M}{r_i}$$

$v_i = 8.00\,\mathrm{m/s} \quad v_f = 0.0\,\mathrm{m/s}$

$r_i = 11.3\times10^{3}\,\mathrm{m} \quad r_f =$

$$\Rightarrow \quad -G\frac{M}{r_f} = \frac{1}{2}v_i^2 - G\frac{M}{r_i}$$

$$\Rightarrow \quad G\frac{M}{r_f} = G\frac{M}{r_i} - \frac{1}{2}v_i^2 \quad \Rightarrow \quad \frac{1}{r_f} = \frac{1}{r_i} - \frac{v_i^2}{2GM}$$

a) $$\frac{1}{r_f} = \frac{1}{11.3\times10^{6}\,\mathrm{m}} - \frac{(8.00\,\mathrm{m/s})^2}{2\times6.67\times10^{-11}\,\mathrm{Nm^2/kg^2}\times1.06\times10^{16}\,\mathrm{kg}}$$

$$\frac{1}{r_f} = 8.85\times10^{-5} - 4.52\times10^{-5}\,\mathrm{m^{-1}} = 4.37\times10^{-5}\,\mathrm{m^{-1}} \Rightarrow r_f = 2.29\times10^{4}\,\mathrm{m}$$

$$= 22.9\,\mathrm{km}$$

b) $K_f + U_{gf} = K_i + U_{gi} \qquad r_f \to \infty \quad v_f \to 0$

$$\cancel{\tfrac{1}{2} m v_f^2} - \cancel{G\frac{mM}{r_f}} = \frac{1}{2}mv_i^2 - G\frac{mM}{r_i}$$

$$\Rightarrow \frac{1}{2}\cancel{m}v_i^2 = G\frac{\cancel{m}M}{r_i} \Rightarrow v_i^2 = \frac{2GM}{r_i} \Rightarrow v_i = \sqrt{\frac{2GM}{r_i}}$$

$$= \sqrt{\frac{2\times6.67\times10^{-11}\,\mathrm{Nm^2/kg^2}\times1.06\times10^{16}}{11.3\times10^{3}\,\mathrm{m}}}$$

$$\Rightarrow v_i = 11.2\,\mathrm{m/s}$$

DIAGNOSTIC