GRAVITY & KINEMATICS

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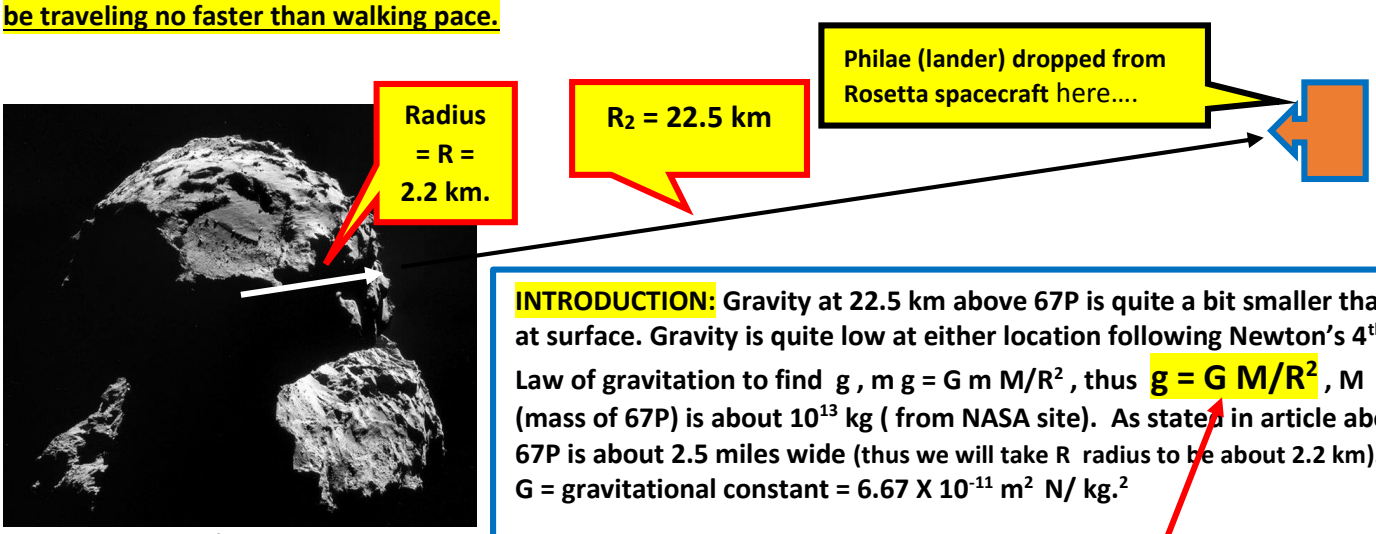
Philae Lander Nears a Cosmic Touchdown

European Space Agency In its 10-year chase of a comet, the European Space Agency's ambitious Rosetta mission has pushed the edges of engineering ingenuity. To the relief of mission managers, Rosetta woke up from its cold, deep sleep as scheduled in January. In August, it finally pulled up alongside the comet, known as 67P/Churyumov-Gerasimenko, both flying closer to the sun at 34,400 miles per hour. In the months since, Rosetta has snapped photographs just 4.5 miles above the craggy surface. Now it is attempting its greatest feat yet: drop a small lander onto the comet. On Wednesday, at 3:35 a.m. Eastern time, **the 220-pound lander, named Philae, detached from Rosetta(& dropped 22.5 km. to surface) and began to be pulled downward by the comet's gravity.** Philae will be aimed at a landing site that covers about a third of a square mile; the area looks relatively smooth and clear of boulders but is still close to streams of dust and gas shooting off the surface. **(((Seven hours later))),** give or take some minutes, **Philae is to bump onto the surface**. **(((The comet, 2.5 miles wide))), is so small and its gravity so slight that even after that long fall, Philae will be traveling no faster than walking pace.**



composite image of Comet 67P, where the Philae lander is scheduled to land after detaching from the Rosetta orbiter.

INTRODUCTION: Gravity at 22.5 km above 67P is quite a bit smaller than at surface. Gravity is quite low at either location following Newton's 4th Law of gravitation to find g , m g = G m M/R^2 , thus $g = G M/R^2$, M (mass of 67P) is about 10^{13} kg (from NASA site). As stated in article above 67P is about 2.5 miles wide (thus we will take R radius to be about 2.2 km). G = gravitational constant = 6.67 X 10^{-11} m^2 N/ $kg.^2$

QUESTIONS: (a) Convert 7 hours into seconds? (b) Convert 22.5 km. to meters?

(c) Knowing distance (22.5 km.) Philae (the lander) dropped to surface of 67P in 7 hours, find average gravity acceleration on 67P? Assume initial velocity was zero. (d) When Philae landed the claim in article was it was traveling at walking speed. Find the speed (in ft./s.) it landed on 67P comet? (e) Gravity is very weak on 67P. At 22.5 km.(where released to fall) g is much lower than at the surface of 67P. Find g at 22.5 km.? (f) Find g at surface (R = 2.2 km.)? , (h) Find average g between surface and 22.5 km. ? (i) Compare this average g in (h) to g found using kinematics in (c) ?

HINTS: $V = V_o + a\,t$, $X = V_o\,t + ½\,a\,t^2$, 1000 m. = 1 km. , 3600 s. = 1 hour , 0.305 meters/foot ,

ANSWERS: (a) ~ 25,200 seconds , (b) 22,500 meters , (c) ~ 0.709 X 10^{-4} $m/s.^2$, (d) ~ 1.79 m/s. or ~ 5.86 ft./s.

(e) ~ 0.0132 X 10^{-4} $m./s.^2$, (f) ~ 1.378 X 10^{-4} $m./s.^2$, (g) ~ 0.7 X 10^{-4} $m./s.^2$, (h) Using kinematics or Average g from Newton's 4th law derivation, the average g on Philae is quite small ~ 10^{-4} $m./s.^2$.