CENTRIPETAL FORCE & ENERGY* Units 14 & 10,11 Dr. John P. Cise

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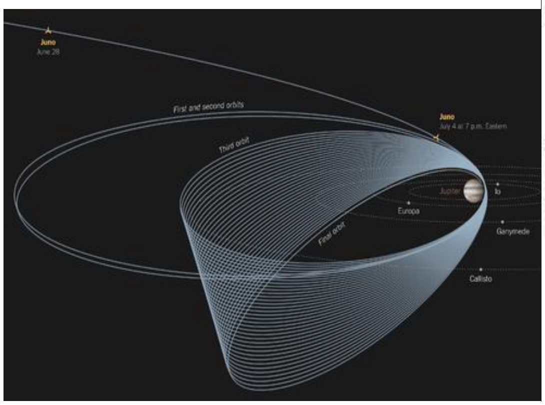
& New York Times , June 28, 2016 by Kenneth Chang

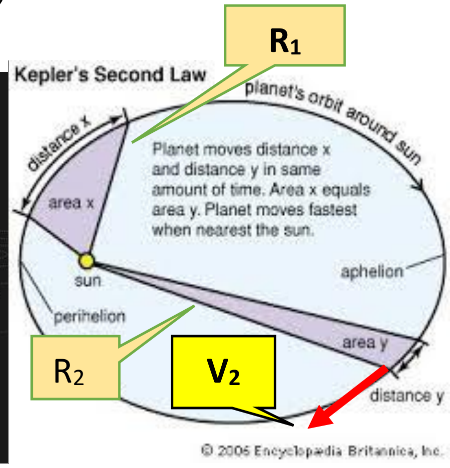
NASA's Juno Spacecraft Will Soon Be in Jupiter's Grip

On July 4, 2016, NASA's Juno spacecraft will arrive to study Jupiter after a trip of nearly two billion miles.

By DENNIS OVERBYE, JONATHAN CORUM and JASON DRAKEFORD on Publish DateJune 28, 2016. . Watch in Times Video »

After traveling for five years and nearly 1.8 billion miles,NASA's Juno spacecraft will announce its arrival at Jupiterwith the simplest of radio signals: a three-second beep. NASA expects the beep, marking the end of a 35-minute engine burn to slow the spacecraft down and allow it to be captured by Jupiter's gravity, to arrive at Earth at 11:53 p.m. Eastern time next Monday. "I can tell you when that completes, you're going to see a lot of celebration," said Rick Nybakken, Juno's project manager, "because that means we'll be in orbit around Jupiter, and that'll be really cool."





INTRO: **Kepler's 2nd. Law states: planets, moons, satellites sweep Out equal areas in equal amounts of time. Thus in triangles at left:**

$$[\ \tfrac{1}{2} R_1\, x\ ]/t = [\ \tfrac{1}{2} R_2\, y]\ /\ t$$

$$R_1 V_1 = R_2 V_2$$

Jupiter has a 43,441-mile radius and must be considered as part of R. Thus, R_2 = 2,043,441 miles & R_1 = 43,441 + 3,100 = 46,541 miles

QUESTIONS: **(a) Find V_2 in mph & m/s?**

HINTS: **0.44704 m./s. = 1 mph**

ANSWERS: **(a) 2846.975 mph, 1,272.7 m/s**

"Juno is to make a series of 37 highly elliptical orbits passing over Jupiter's north and south poles over 20 months. **((At its farthest, it will be about two million miles (R_2) from Jupiter. For each orbit, it will accelerate inward, reaching 128,000 miles per hour(V_1), and pass within 3,100 miles(R1) of Jupiter's cloud tops)).** **The slight fluctuations in Jupiter's gravitational pull, measured by shifts in the frequency of Juno's radio signals, will tell the density of the planet's interior and whether there is a rocky core within, where pressures might reach half a billion pounds per square inch.**

Scott Bolton, the principal investigator for the $1.1 billion mission, with a model of the solar-powered spacecraft.

INTRODUCTION 2: **Total energy is conserved of Juno satellite ……..**

$$K_1 + U_1 = K_2 + U_2, \quad \text{or} \quad \tfrac{1}{2} m V_1^2 + [-\,Gm\,M_J/R_1\,] = \tfrac{1}{2} m V_2^2 + [-\,Gm\,M_J/R_2\,] \qquad \text{eq. 1}$$

Note in eq. 1 instead of mgh for U(gravitational potential energy) used is -G m M/R since this function accounts for changes in gravity with distance.

Our goal here is to show total energy is conserved with data above about: V_1, V_2, R_1, R_2.

Lets rearrange terms in eq. 1 (& remove m from all terms) to reflect ΔK = ΔU for the fact that total kinetic energy changes should be equivalent to potential energy changes….

$$[\,V_1^2 - V_2^2\,]/2 = G\,M_{Jupiter}\,[\,1/R_1 - 1/R_2\,] \qquad \text{eq. 2}$$

QUESTIONS: **(a) Convert Perigee 128,000 mph to m./s. (V_1)?**
(b) Compute left side of eq. 2? (c) Find Perigee R_1 in meters? (d) Find Apogee R_2 in meters? (e) Compute right side of eq. 2? (f) Comment on how well computed energy conservation came out finding kinetic energy change vs. gravitational potential change?

HINTS: **G (gravitational constant) = 6.67408×10^{-11} N m^2/ kg.^{2} , $M_{Jupiter} = 1.898 \times 10^{27}$ kg.**

ANSWERS: **(a) V_2 = 57,221.12 m./s. , (b) 1.636×10^9 , (c) R_1 (perigee) = 7.49×10^7 meters (d) R_2 = 3.28859×10^9 meters, (e) 1.6715×10^9 (f) Left and right side of eq. 2 are within 1 % (1.636×10^9 vs. 1.6715×10^9). This is quite good considering article data on peragee and apogee are approximations to reality. Convincing energy is conserved.**