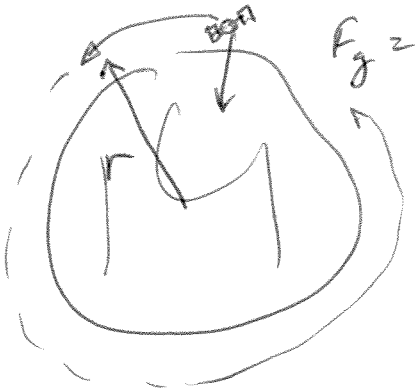
General Problem Solving Guide

Date:
Recorder: KEY
Skeptic:
Timekeeper:
Psychic:

List given information, define variables, sketch picture:



$F_g = \frac{GM_E m}{r^2}$

$r \approx R_A$

[2]

Assume spherical orbit

$\rho_A = \frac{M_A}{\frac{4}{3}\pi R_A^3}$

Simplify question, list target quantity:

[1] Find T for near surface orbit

List all related quantitative relationships:

$a_c = \frac{v^2}{r}$ $F_g = +\frac{GMm}{r^2}$ $T = \frac{D}{v}$

[2] $\sum \vec{F} = \frac{d\vec{p}}{dt} = m\vec{a}$ since mass is constant

Outline approach, sketch diagrams if needed (or sketch next to pictures above):

If they didn't have forces on diagram but mentioned using forces, I dinged 1 pt

Find orbital velocity using force momentum principle.

Find period (distance divided by time).

Check answer.

-1/2

Obtain a general solution:

$$\frac{GM_A m}{r^2} = m\frac{v^2}{r}$$

$M_A = \rho \frac{4}{3}\pi R_A^3$ $\quad r \approx R_A$ $\quad m$ cancels

[1] $\frac{G\rho\frac{4}{3}\pi R_A^3}{R_A^2} = \frac{v^2}{R_A}$

$\left[G\rho\frac{4}{3}\pi R_A^2\right]^{1/2} = v$ orbital velocity

$T = \frac{D}{v} = \frac{2\pi R_A}{v}$

$= \frac{2\pi R_A}{R_A(G\rho\frac{4}{3}\pi)^{1/2}}$

Dinged $-\frac{1}{2}$ if they didn't simplify

$T = \left[\frac{4\pi^2}{G\rho\frac{4}{3}\pi}\right]^{1/2}$

$T = \left[\frac{3\pi}{G\rho}\right]^{1/2}$

only dependent on density!

DRC is correct!

NOTE? keep $r \neq R_A$ $\quad r = R_A + h$

$T = \left(\frac{3\pi}{G\rho}\right)^{1/2}\left(1+\frac{h}{R_A}\right)^{3/2}$ $\quad h\uparrow T\uparrow$ $\longrightarrow$ makes sense

Check Units:

$\left[\frac{m}{s}\right] = \left(\frac{N m^2}{kg^2}\frac{m^2}{m^3}\right)^{1/2}\left(\frac{kg\,m}{s^2\,kg^2}\frac{m^4}{m^3}\frac{kg}{}\right)^{1/2}$

[1] $= \left(\frac{s^2}{kg^2}\cdot\frac{m^5}{m^3}\frac{1}{s^2}\right)^{1/2}\left(\frac{m^2}{s^2}\right)^{1/2} = \left[\frac{m}{s}\right]$ ✓

Check Limiting Cases:

$\rho\downarrow$ $\quad T\uparrow$ makes sense since F_g decreases

[1] lot of them have no clue!

Obtain a numeric solution:
(i.e. plug in the numbers)

[1] $T = \left[\frac{3\pi}{G\rho}\right]^{1/2}$ I was generous if they punched in #s

Why is solution reasonable? Explain.

Check for ISS

$\left(\frac{3\pi}{6.67\times10^{-11}\cdot 5520}\right)^{1/2} \approx 5059$ sec

[1] A lot don't know what to do here $= 84$ min 19 sec

This is close to 90m so equation is reasonable!