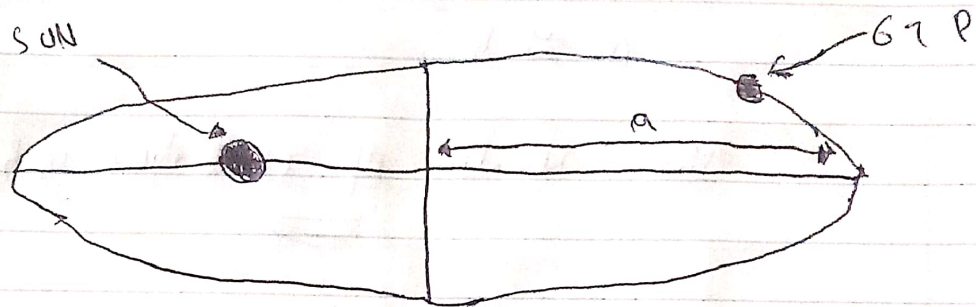PHYS-230

LAB QUIZ #13

The Rosetta mission was the first one to land
a spacecraft on a comet, specifically comet 67P
/Churyumov-Gerasimenko. 67P has a semi major
axis $a = 3.4630$ AU with an eccentricity
$e = 0.64162$

(a) What is the velocity of 67P at the aphelion (point
of maximum distance to the sun)?

(b) What is the total mechanical energy of this comet?

(c) What is its velocity at the perihelion (point of mini-
mum distance to the sun)?

(d) What is the velocity of 67P at a distance $r = 4.1283$ AU
from the sun?

(e) What is the orbital period of 67P? (For this question you
may assume a circular orbit with radius equal to a).

DATA:

$G = 6.6728 \times 10^{-11} \frac{N \, m^2}{kg^2}$

P.T.P

$M_{67P} = 9.982 \times 10^{12}$ kg

$M_{sun} = 1.989 \times 10^{30}$ kg

$1 AU = 1.495978707 \times 10^{11}$ m

Ans.- (a) $V_{aphelion} = \sqrt{\dfrac{G M_{sun}}{a} \left(\dfrac{1-e}{1+e}\right)}$

$$= \sqrt{\dfrac{6.6725 \times 10^{-11} \times 1.989 \times 10^{30}}{10^{11} \times 3.4630 \times 1.495978707}\left(\dfrac{1-e}{1+e}\right)}$$

$$= \sqrt{\dfrac{2.56180142 \times 10^{8} \times 0.35898}{1.64102}}$$

$$= \sqrt{0.560404792 \times 10^{4}}$$

$$= 7486.0 \text{ m/s}$$

∴ The velocity of 67P at the aphelion is 7486 m/s

(b) $\varepsilon = -\dfrac{G M_s M_c}{2a}$

$\varepsilon = -\dfrac{6.6725 \times 10^{-11} \times 9.982 \times 1.989 \times 10^{42}}{2 \times 3.4630 \times 1.495978707 \times 10^{11}}$

$\varepsilon = -12.7859504 \times 10^{20}$ J

The total mechanical energy of this comet
$= -12.7859504 \times 10^{20}$ J

(2)

P.T.o

(c) $V_{perihelion} = \sqrt{\dfrac{GM_{sun}}{a}\left(\dfrac{1+e}{1-e}\right)}$

$= \sqrt{\dfrac{6.6725 \times 10^{-11} \times 1.989 \times 10^{30} \times 1.64102}{10^{11} \times 3.4630 \times 1.499978707 \times 0.35898}}$

$= 10^{4} \sqrt{11.7108679}$

$= 34221.1 \ m/s$

Velocity at the perihelion $= 34221.1 \ m/s$

(d) $V = \sqrt{GM_s\left(\dfrac{2}{r} - \dfrac{1}{a}\right)}$

$V = \sqrt{\dfrac{6.6725 \times 10^{-11} \times 1.989 \times 10^{30}}{1.499978707 \times 10^{11}}\left[\dfrac{2}{4.1283} - \dfrac{1}{3.4630}\right]}$

$V = 13176.1 \ m/s$

Velocity of 67P at a distance $r = 4.1783 \ AU$
$= 13176.1 \ m/s$

(e) $T = 2\pi \sqrt{\dfrac{a^3}{GM_{sun}}}$

$T = 2\pi \sqrt{\dfrac{(3.4630)^3 \times (1.499978707)^3 \times 10^{33}}{6.6725 \times 10^{-11} \times 1.989 \times 10^{30}}}$

$= 2\pi \sqrt{10.4763583 \times 10^{14}}$

$T = 20.3369134 \times 10^{7} \ S$