1. Find the orbital period (period of revolution) of Jupiter if its distance from the Sun is about 7.8×10^8 km. ($a_e = 1.5\times10^8$ km).

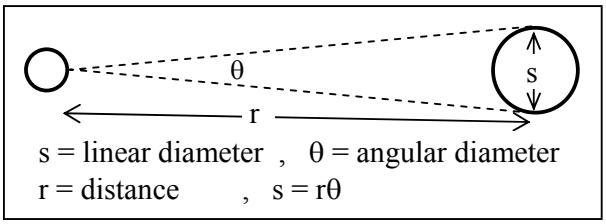
   $a = 7.8\times10^8$ km $= 7.8\times10^8 / 1.5\times10^8 = 5.2$ a.u.
   $T^2 = a^3$ ➔ $T = a\sqrt{a} = 5.2 \times \sqrt{5.2} = 11.86 = 12$ yrs.

2. Find the orbital period of Jupiter if its distance from the Earth is about 6.3×10^8 km when it is in opposition with the Sun. ($a_e = 1.5\times10^8$ km).

   $a = 6.3\times10^8$ km $+ 1.5\times10^8 = 7.8\times10^8$ km $= 7.8\times10^8 / 1.5\times10^8 = 5.2$ a.u.
   $T^2 = a^3$ ➔ $T = a\sqrt{a} = 5.2 \times \sqrt{5.2} = 11.86 = 12$ yrs.

3. Find the orbital period of Jupiter if its angular diameter is about 47" as seen from the Earth when it is in opposition with the Sun. ($a_e = 1.5\times10^8$ km, $R_J =$ 71500 km)

   $\theta = 47" = (47/3600)° = 0.013°$
   $= 0.013*\pi/180$ rad
   $= 0.00023$ rad.
   s = diameter $= R_J \times 2 = 71500 \times 2$
   $= 143000$ km
   $s = r\theta$ ➔ $r = s/\theta = 143000 / 0.00023$
   $= 6.3\times10^8$ km



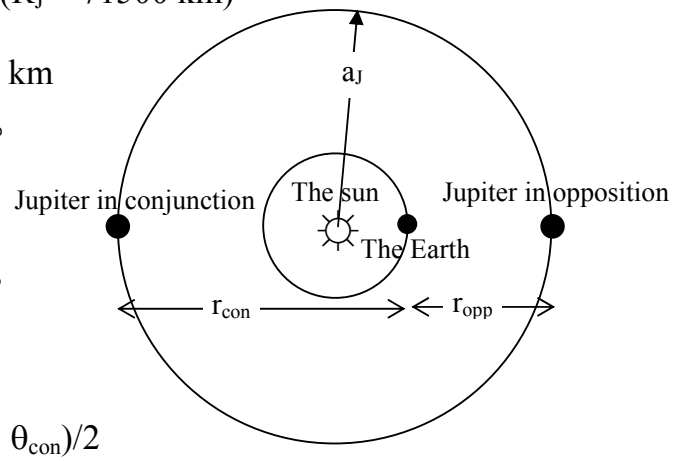
   $a = 6.3\times10^8$ km $+ 1.5\times10^8 = 7.8\times10^8$ km $= 7.8\times10^8 / 1.5\times10^8 = 5.2$ a.u.
   $T^2 = a^3$ ➔ $T = a\sqrt{a} = 5.2 \times \sqrt{5.2} = 11.86 = 12$ yrs.

4. It is found that the angular diameter of Jupiter at opposition is $\theta_{opp} = 47"$ and it is $\theta_{con} = 32"$ at conjunction with the Sun as seen from the Earth. Find the distance of Jupiter from the Sun. ($R_J = 71500$ km)

   $S = 2 \times R_J = 2 \times 71500 = 143000$ km

   $\theta_{opp} = 47" = 47 / 3600° = 0.013°$
   $= 0.013 \times \pi / 180$ rad.
   $= 0.00023$ rad.

   $\theta_{con} = 47" = 32 / 3600° = 0.009°$
   $= 0.009 \times \pi / 180$ rad.
   $= 0.00016$ rad.



   $a_J = (r_{opp} + r_{con})/2 = (s / \theta_{opp} + s / \theta_{con})/2$
   $= 143000(1/0.00023 + 1/0.00016)/2$
   $= 143000(10598)/2 = 7.6\times10^8$ km

5. In order to find the mass of the Moon a space craft is made to orbit around it. Find the mass of the Moon if the space craft is orbiting at a height of 127 km above its surface with a period of 2 hrs. Also find the orbital speed of the space craft.(R_m = 1738 km, G = 6.67×10^{-11} $m^3/kg.s^2$)

$T^2 = (4\pi^2/GM_m)\, a^3$ ➔ $M_m = 4\pi^2\times a^3/G\times T^2$

$= 4\pi^2\times(127000 + 1738000)^3/G\times(2\times3600)^2 = 7.4\times10^{22}$ kg

$v = 2\pi\times a/T = 2\pi\times(127 + 1738)/2 = 5859$ km/hr = 1.63 km/s

$v = \sqrt{G\times M/a} = \sqrt{6.67\times10^{-11} \times 7.4\times10^{22} / (127000 + 1738000)} = 1627$ m/s

= 1.63 km/s

6. How long Hubble Space Telescope (HST) takes (in minutes) to circle once around the Earth if it is at a height of about 600 km above the Earth surface? ($R_\oplus$ = 6400 km, G = 6.67×10^{-11} $m^3/(kg.s^2)$, $M_\oplus = 6\times10^{24}$ kg)

$P^2 = (4\pi^2 / G M)\, a^3$

$P = \sqrt{4\pi^2 (600000+6400000)^3 / 6.67\times10^{-11} \times 6\times10^{24}}$

= 5817 seconds = 97 minutes

---

7. How fast Hubble Space Telescope (HST) is moving (in km / s) as it circles the Earth at a height of about 600 km above its surface? ($R_\oplus$ = 6400 km, G = 6.67×10^{-11} $m^3/(kg.s^2)$, $M_\oplus = 6\times10^{24}$ kg)

$P^2 = (4\pi^2 / G M)\, a^3$ ➔ $P^2 / (4\pi^2 a^2) = (1 / G M)\, a = 1 / v^2$

$v = \sqrt{G M / a} = \sqrt{6.67\times10^{-11} \times 6\times10^{24} / (600000+6400000)}$

= 7561 m / s = 7.6 km / s

or $v = 2\pi a / P = 2\pi(600000+6400000) / 5817 = 7561$ m/s = 7.6 km / s

---

8. How fast Hubble Space Telescope (HST) is moving (in degrees per minute) as it circles the Earth at a height of about 600 km above its surface? (P = 97 min.)

360 º in P sec. ➔ ɵ º in 1 sec

ɵ = 360 / P = 360 / 97

= 3.7 º / min. = 223 º / hr.

= 14.85 revolutions per day

= about 15 rev. per day

Phys 215:
alshukri@kfupm.edu.sa

Introduction to Astronomy
Physics Department
KFUPM , Dhahran
Saudi Arabia