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ATMOSPHERIC DRAG PERTURBATION EFFECT ON THE SATELLITES ORBITS

Abdul_Rahman Hussain Salih

Sciences of college/ University of Baghdad.

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ABSTRACT

In this paper the drag perturbation for the law orbit are studded ,Koll-method is suitable to used hear, equation of motion it's solved by numerical integration ;Rang-Kota-method was used ; to find the components of velocity and position and find the orbital parameters with perturbation .Study the effect of drag perturbation on the position , of satellite with time and on perigee , apogee , a ,e and age of satellite, Study the variation of satellite position and age with height we can increase the age of satellite to 40 times by increase the perigee height only 2 times, and by decrease A/m ratio and eccentricity also by rotate in the direction of the earth rotate.

Introduction

The orbital perturbation are the mean division for the magnitude of orbital elements because the outer moments on the satellite. The perturbations are classified to gravitational as" the earth geiodiset and outer gravity of the moon and sun on the satellite" ,and un gravitational as" the atmospheric drag and the prosier of the solar radiation ",this type depend on the geometry of the satellite and the atmosphere composition and density .

The equation of two body motion with out perturbations can be solved by using Newtion gravitational law and Kipler laws ,but with perturbations

The solution is more difficult. There are two methods of solution ; the first one is by using numerical integration step by step and the second is analytical solution for multiplier terms and time integration for orbital parameters as " Gaus-method with un gravitation and Lagrang-method with gravitation [1,2,3].

In this paper the drag perturbation for the law orbit are studded.

Theory:

The solution of orbital equation with perturbations :

In this case the equation can be written as: Where a: all the acceleration perturbations on the moving body which is a victor and a << M r / r

Koll-method is suitable to used hear which is:

After that integrate the equation of motion

2-Atmospheric drag calculation:

Drag is more important with lower orbits { < 1000 km }, where the atmosphere is more density that's miens more collision with satellite body .

The drag make a decreasing in velocity or in kinetic energy of satellite and decrease the orbit radius

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* Corresponding author at: Sciences of college/ University of Baghdad, Iraq.E-mail address:

and the time period (T^2 a^3=M). After many period the satellite is full down and destroy [2,3,4].

Koll-method is used with numerical integration for the equation of motion with perturbation. The relative velocity (Vr) is determined with many orbit radius and (A/m) ratio "area to mass of satellite", and determine the age of satellite. In the beginning we chose a magnitude for perihelion height (h) and determine a=h +a. a program in Q.-basic was balding by using the following steps:

The atmosphere density was determine as in the following:

ρ = ρ exp((h – h.)/ H) . (3)

h: height , h : perihelion height , ρ:atmosphere density at perihelion

H: constant scale height, ρ =0 at height >1000 km. and ρ =9.8*10^-9 kg/m at height 100km. [4].

2- The relative velocity (v)is summation of orbital velocity (v) and atmosphere velocity (r * w) ,where w : earth angular velocity=1/86164 rad/sec and r: position of satellite from the earth center and the orbital velocity derivative in ref. [5].

v^2 = μ (2/r – 1/a) (4)

V=v+r*w (5)

$$r = (x^2 + y^2 + z^2)^{1/2}$$

$$V_r = \frac{x\dot{x} + y\dot{y} + z\dot{z}}{r} = \frac{r\dot{r}}{r} \qquad (6)$$

Vr(mag) =√(Vrx^2 + Vry ^2+Vrz ^2) (7)

Where Vrx = x˙ + w y ,

Vry = y˙ - w x , Vrz = z˙

Vrx (unit) = Vrx / Vr(mag) , Vry(unit) = Vry/ Vr(mag) , Vrz(unit) = Vrz/ Vr(mag) (8)

3- The atmospheric drag the friction that a satellite encounters as it passes through the diffuse upper layers of the earth’s atmosphere.

The magnitude of the drag acceleration is :

$$a_D = \frac{A\rho_g C_D}{2m_s} Vr^2(mag) \qquad (9)$$

Where A is the effective cross- sectional area of the body, The atmospheric density ρ at the geocentric distance r, CD is the drag coefficient Vr(mag) is the satellite– atmosphere relative speed, ms mass of satellite.

The force acts, when the atmosphere is regarded as static, opposite to the satellites velocity vector in the negative tangential direction.

Radiation pressure: electromagnetic radiation carries energy, momentum, angular momentum within. Then the radiation exerts a pressure. Its effect on artificial satellites are especially noticeable on the balloon – type satellites, this force is time dependent and usually treated in the Gaussian formulation of the perturbation equations. The magnitude of solar radiation pressure force is given by

$$(10)\ \frac{AP_o}{4\pi mcD_s^2}\ Fp =$$

Where A/m is the effective cross – sectional area on mass of the satellite, P¤ is the total radiation solar power, c is the speed of light in vacuum, Ds satellite sun distance .Solar radiation pressure is caused by collisions between the satellite and photons radiating from the sun, which are absorbed or reflected this drag is neglect hear.

4- Substitute the components from equations (8) in equation (9) get the components of acceleration drag :

aDx = aD * Vrx (unit)
aDy = aD * Vry (unit) (11)
aDz = aD * Vrz (unit)

5-Substitute the components from equation (11) in equation (1) and it's solved by numerical integration ;Rang-Kota-method was used ; to find the components of velocity and position and find the orbital parameters with perturbation .

aD(mag) =√(aDx^2 + aDy^2 + aDz^2

The step of work as the following flow chart:

Results and discussion

The input data are hp=95.805 km. (where the drag is clear)_ orbital radius a =6552.6 km. ,eccentricity e = 0.012 ,inclination i = 98.7 deg. , Ω=273 deg. ,w = 100 deg.,Cd=2.1 ,m=900kg., A=5.1 m., there are the same input data for reference [28] to comparison the results. Study the effect of drag perturbation on the position , of satellite with time and on perigee , apogee , a ,e and age of satellite in fig (1,2,3,4,5,6,7) we show that:

fig (1) show that the drag reduced the position r with time for five periods also the apogee quickly reduced with time from the perigee after that the satellite destroy near the earth surface . also we show that the period is 96 min. is constant and the age of satellite is 7.4 hr.

Fig (2) show that with the velocity with perturbation near perigee is more increase and in apogee is constant the variation is opposite in fig (1). In two figs (1,2) the difference between min.and max. Values is reduced and the orbit is became semi circle with time that clear in fig (3). The satellite loss the energy difference (E=k.E. +p.E.) in last period ,it's full down on the earth surface.

Fig (4,5) show that the radius a reduce with time . We see more energy loss in perigee where the drag perturbation is increase with increased the density of air.

Fig (7) show that the eccentricity e =0.012 is reduce with time that means the variation of drag between the perigee and apogee in perigee the drag is more effect, so that e come to zero but the satellite full down at e=0.003

2-Study the variation of satellite position and age with height (h).

The same input parameter magnitude are used with heights (h=200,300, 400 km) the result as a number of period and life time with heights are in the following table:

h (km.)	No. of period	Life time (h.)
200	86	128.494
300	808	1240.903
400	2868	4501.748

This table and figs.(8-a,b,c ;9-a,b,c) shows that the life time is exponentially increase with height because the drag is decrees . that to mean we can increase the age of satellite to 40 times by increase the perigee height only 2 times.

Study the effect of A/m on the orbit motion and on the life time of satellite

fig(10) and table (2) explain that the number of periods and life time reduce with increase A/m , that's because the drag is proportion with A/m as in equation(9).

Fig(11) show that the main radius (a) is inversely proportional with A/m when the other parameters are stay constant , also we show this effects is same for all heights (200,300,400 km.).

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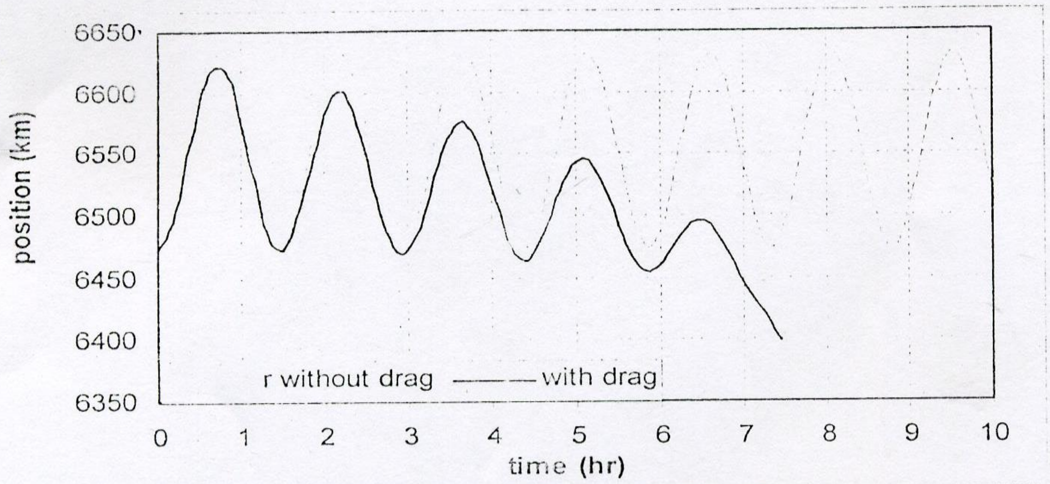
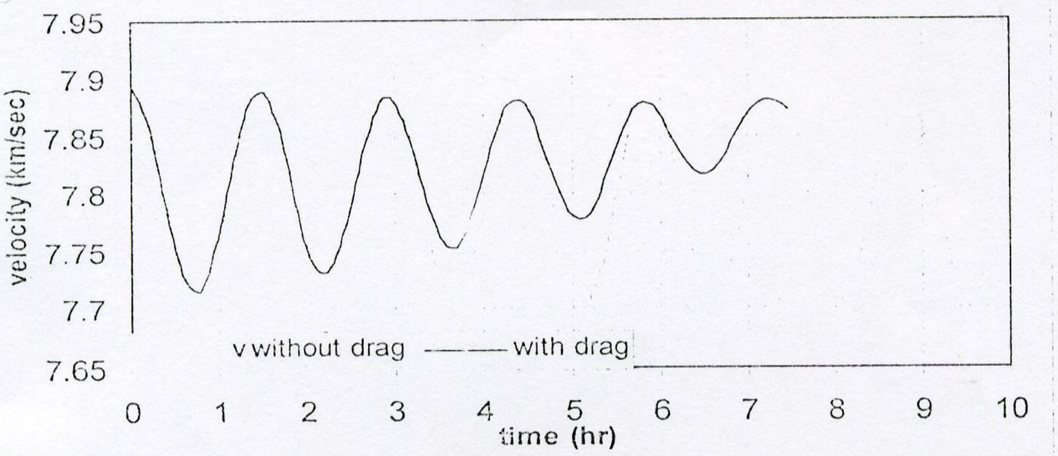
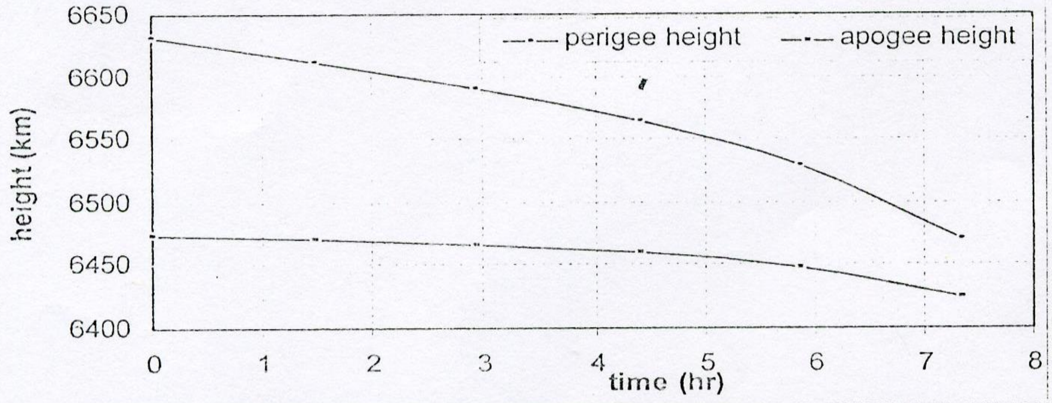


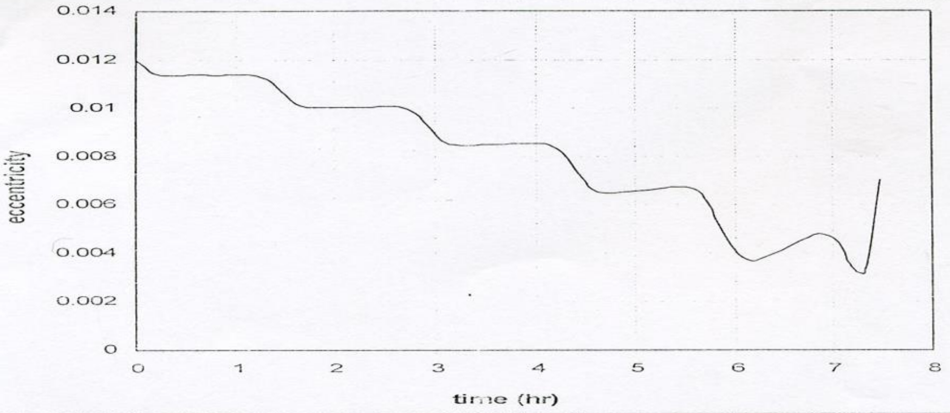
شكل (1) يبين تأثير الكبح على موقع القمر الصناعي اثناء حركته المدارية



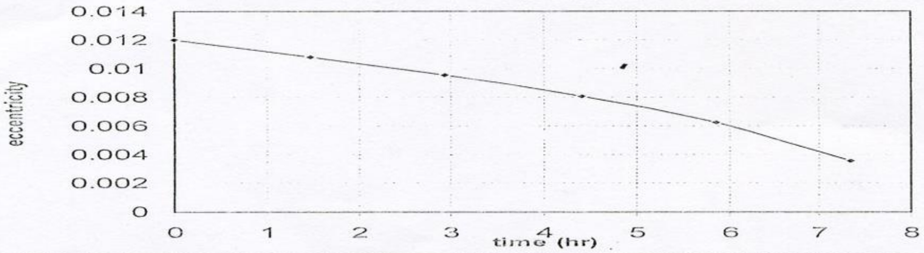
شكل (2) يبين تأثير الكبح على سرعة القمر الصناعي اثناء حركته المدارية



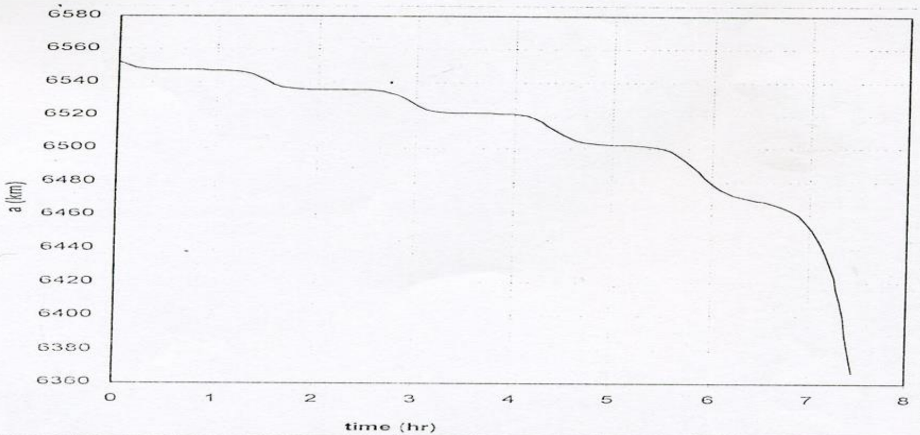
شكل (3) يبين تأثير الكبح على موقعي الاوج و الحضيض عند نهاية كل دورة



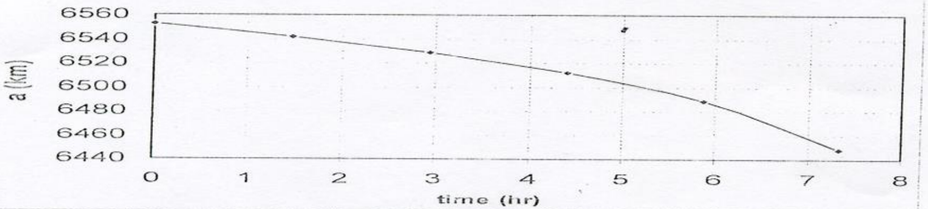
شكل (6) يبين التغيرفي الشذوذ المركزي للمدار مع الزمن اثناء الحركة المدارية



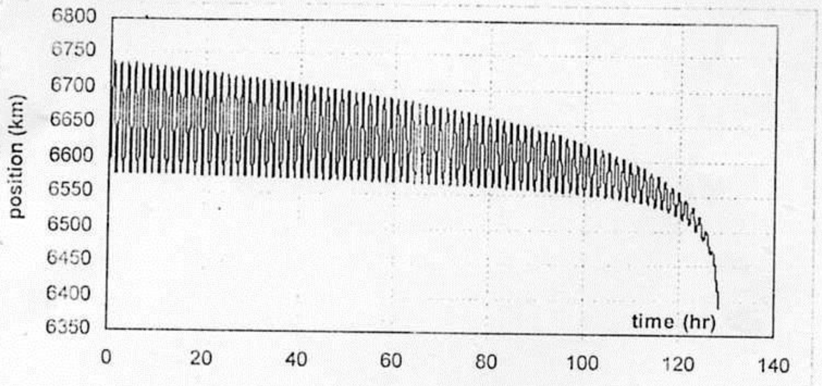
شكل (7) يبين التغيرفي الشذوذ المركزي للمدار مع الزمن عند نهاية كل دورة



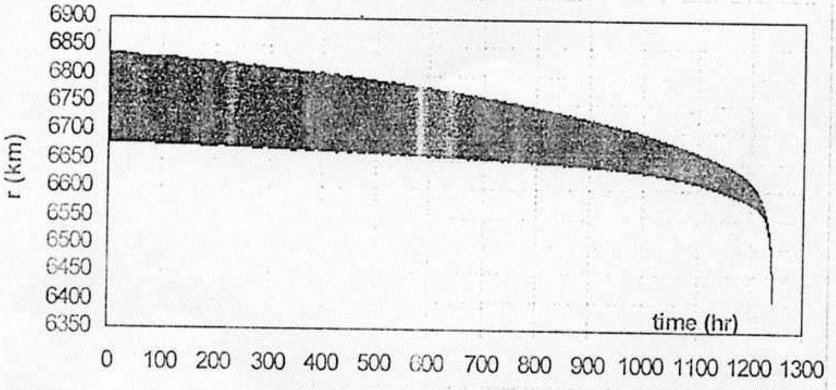
شكل (4) يبين التغيرفي نصف المحور الكبير للمدار مع الزمن اثناء الحركة المدارية



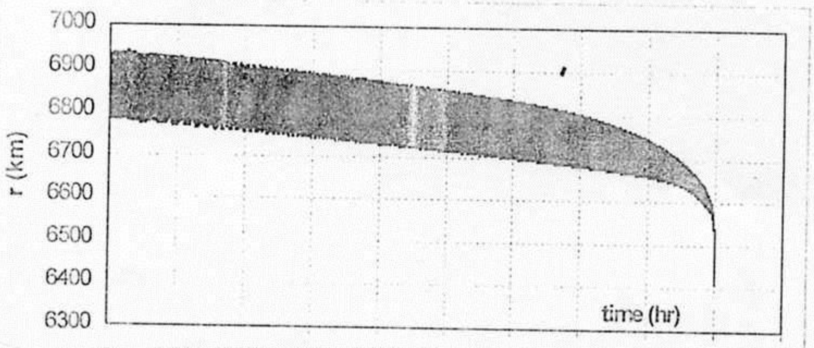
شكل (5) يبين التغيرفي نصف المحور الكبير للمدار مع الزمن عند نهاية كل دورة



شكل (8-a) تأثير الكبح على موقع القمر الصناعي عند الأرتفاع ٢٠٠ كم



شكل (b-8) يبين تأثير الكبح على موقع القمر الصناعي اثناء حركته المدارية عندما $(h_p = 300km)$



شكل (c-8) يبين تأثير الكبح على موقع القمرالصناعي اثناء حركته المدارية عندما $(h_p = 400km)$

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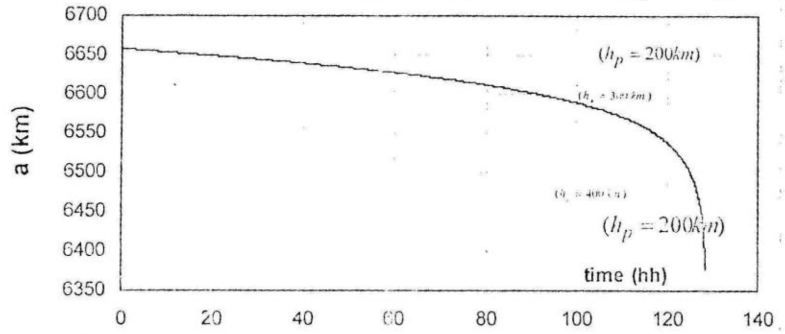
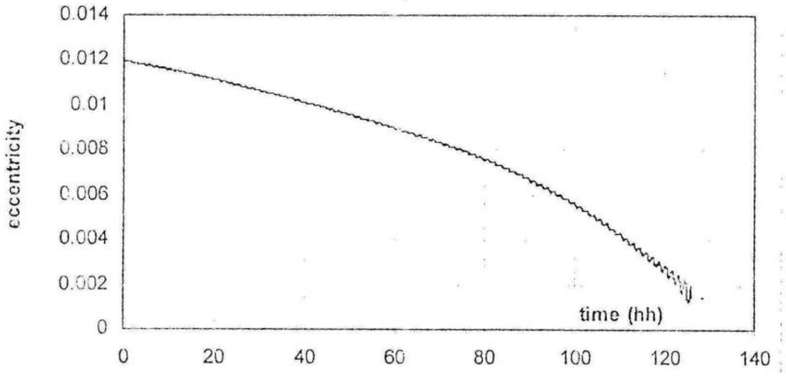
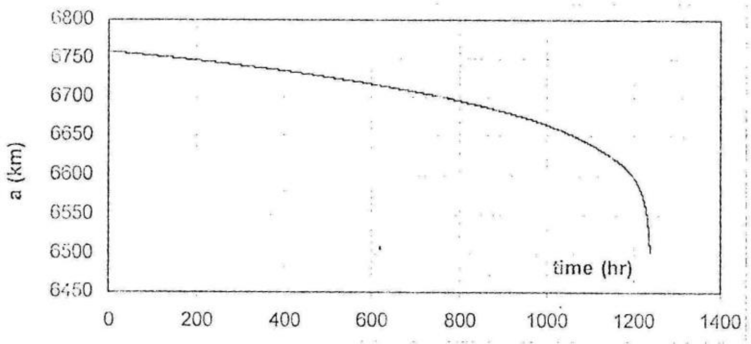


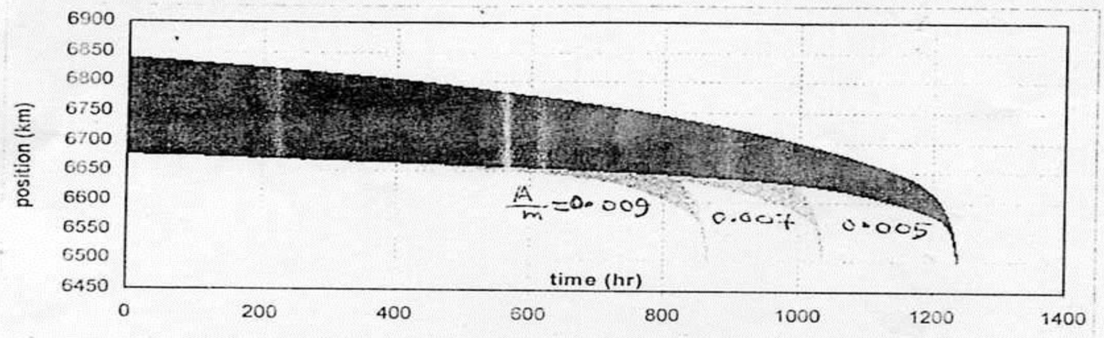
شكل (a-9) يبين تأثير الكبح على نصف المحور الكبير للمدار عندما $(h_p = 200km)$



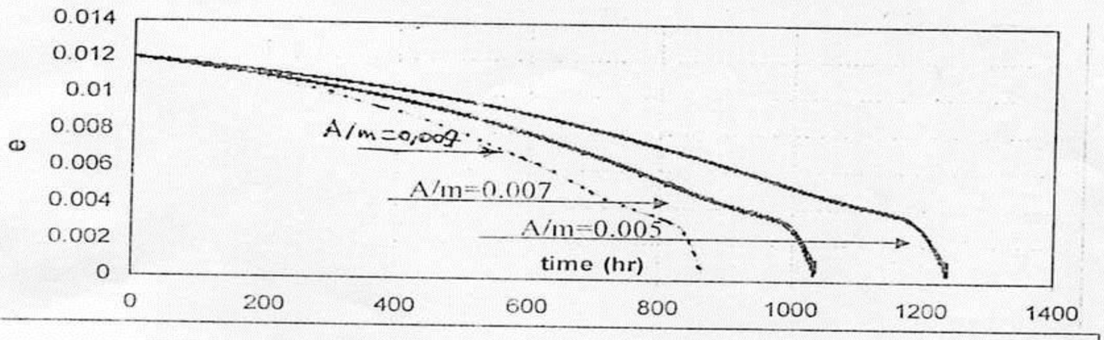
شكل (9-b) يبين تأثير الكبح على الشذوذ المركزي للمدار عندما $(h_p = 200km)$



شكل (9-c) يبين تأثير الكبح على نصف المحور الكبير للمدار عندما

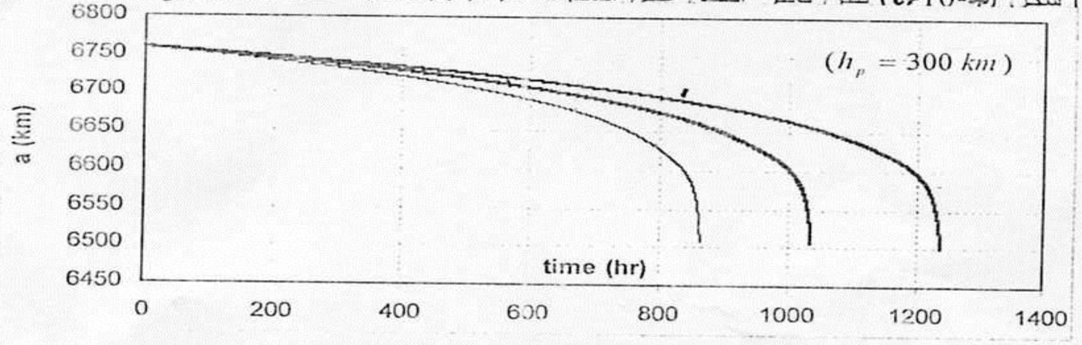


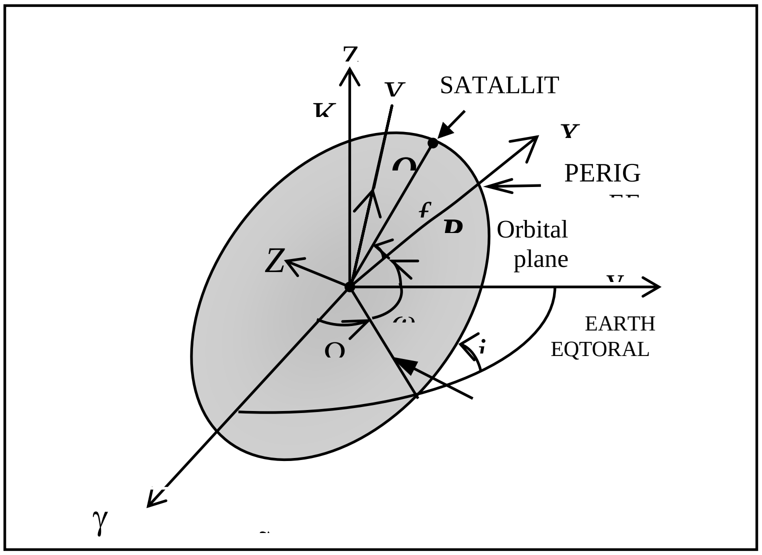
شكل (10-أ) يبين تأثير الكبح على الشذوذ المركزي للمدار عندما $(h_p = 300km)$



شكل (10-ب) يبين تأثير تغير النسبة (A/m) على الشذوذ المركزي (c) اثناء الحركة المدارية

شكل (10-ج) يبين تأثير الكبح على الشذوذ المركزي للمدار عندما $(h_p = 300km)$

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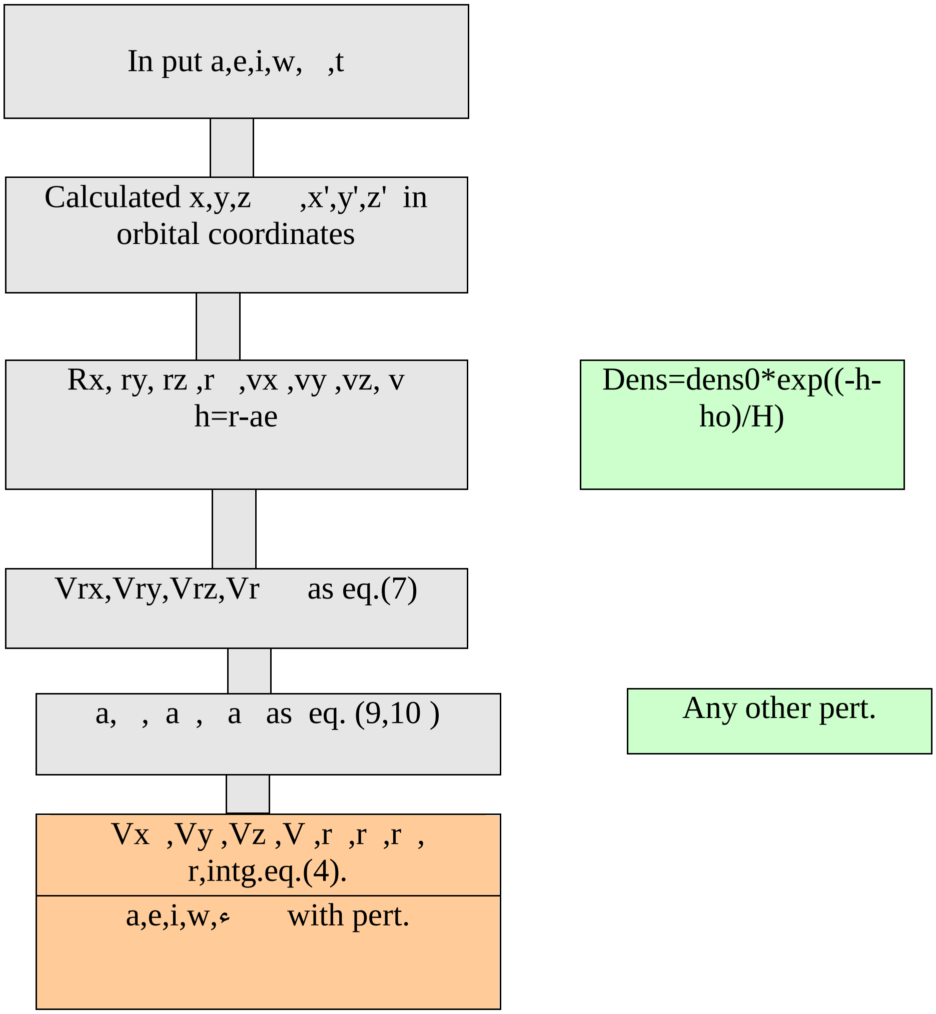
In put a,e,i,w, ,t
Calculated x,y,z ,x',y',z' in orbital coordinates
Rx, ry, rz ,r ,vx ,vy ,vz, v
h=r-ae
Dens=dens0*exp((-h-ho)/H)
Vrx,Vry,Vrz,Vr as eq.(7)
a, , a , a as eq. (9,10)
Any other pert.
Vx ,Vy ,Vz ,V ,r ,r ,r ,
r,intg.eq.(4).
a,e,i,w,ɕ with pert.

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تأثير اضطراب الغلاف الجوي للأرض على مسارات الأقمار الصناعية

عبد الرحمن حسين صالح

الخلاصة:

تم في هذا البحث دراسة تأثير كبح الغلاف الجوي للأرض على مدارات الأقمار الصناعية الواطئة واستخدمت طريقة كول لحساب تغير الموضع والسرعة مع الزمن وهي مناسبة. وتحل بالتكامل العددي واستخدمت طريقة رانج –كوتا لإيجاد مركبات الموضع والسرعة، ثم حساب العناصر المدارية بوجود الاضطراب. تم دراسة اضطراب الكبح على مركبات الموضع للأوج والحضيض و a ,e وعمر القمر الصناعي ر ارتفاع القمر على تلك العناصر .وتوصلنا أنه بالإمكان زيادة عمر القمر الصناعي 40 مرة بزيادة ارتفاع الحضيض مرتين وكذلك تقليل A/m والانحراف المركزي وبتدويره باتجاه برم الأرض .