Home Work #2

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1 Question 1

The space shuttle weighs approximately 12.5 tons, whose thrusters can simultaneously produce a total thrust of 53400 Newtons for orbital maneuvers. Assuming that the shuttle is initially in a 300 Km (altitude) circular Earth orbit, it is desired to use a single impulse to transfer the shuttle to a 250x300 Km elliptical orbit.

1.1 part a

$$h = \sqrt{2\mu}\sqrt{\frac{r_a r_p}{r_a + r_p}}$$

$$v = \frac{h}{r}$$

First orbit (circular):

$$r = 6678$$

For first circular orbit $r_a = r_p$.

$$h = 51593 \rightarrow v = 7.7258_{km/\sec}$$

Second orbit (elliptical):

$$r_p = 6628, \quad r_a = 6678$$

$$h = 51496 \rightarrow v_a = 7.7113_{km/\sec}$$

$$\Delta v = v_a - v = 0.0145_{km/\sec}$$

1.2 part b

$$T = \frac{m\Delta v}{\Delta t} \rightarrow \Delta t = \frac{m\Delta v}{T} = 0.0034_{\sec}$$

1.3 part c

Assuming the velocity is the mean velocity of circular and elliptical velocity.

$$v_{mean} = \frac{v_{circular} + v_{elliptical}}{2} = 7.7186_{km/\sec}$$

$$\begin{aligned}\text{distance} &= v_{mean} \times \Delta t \pm \Delta v \Delta t = 7.7186_{km/\sec} \times 0.0034_{\sec} \pm 0.0145_{km/\sec} \times 0.0034_{\sec} \\ &= 0.0268_{km} \pm 4.9415 \times 10^{-5}_{km}\end{aligned}$$

1.4 part d

Period of the first Orbit:

$$\tau_1 = 2\pi\sqrt{\frac{\mu}{r^3}} = 864.3726_{\sec} \rightarrow \frac{\Delta t}{\tau_1} = 3.9347 \times 10^{-6}$$

Period of the second Orbit:

$$\tau_2 = 2\pi\sqrt{\frac{\mu}{a^3}} = 859.5233_{\sec} \rightarrow \frac{\Delta t}{\tau_1} = 3.9569 \times 10^{-6}$$

1.5 part e

Assume:

$$C_1 = C_2 = 2\pi r = 4.1959e+04 \rightarrow \frac{\Delta d}{C_1} = 1.1777 \times 10^{-9}$$

2 Question 2

We know that $r_1 = r_2$, $\theta_1 = 90^\circ$, $\theta_2 = 0$, and $e_1 = e_2 = e$.

$$r_1 = \frac{h_1^2}{\mu}\frac{1}{1 + e_1\cos(\theta_1)} = r_2 = \frac{h_2^2}{\mu}\frac{1}{1 + e_1\cos(\theta_2)} \xrightarrow[e_1=e_2=e]{\theta_1=90^\circ,\ \theta_2=0} \frac{h_1^2}{1+e} = h_2^2 \rightarrow h_2 = \frac{h_1}{\sqrt{1+e}}$$

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