1) General equation of conic -

$$Ax^2 + By^2 + Cxy + Dx + Ey + F = 0$$

$0.0944A + 0.3869B + C(0.1912) - D(0.30738) - E(0.622$
$+ F = 0$

$(13.635)A + B(11.410) + C(12.4733) + D(3.6926) + E(3.377) + F$

$(22.020)A + B(0.14282) + C(1.7734) + D(4.6926) + E(0.377) + F = 0$

$(13.635)A + B(0.3869) + C(-2.2971) + D(3.6926) + E(-0.6220) + F$

$(32.405)A + B(11.4103) + C(19.229) + D(5.6926) + E(3.3779)$
$+ F = 0$

$(0.4797)A + (5.6545)B + C(1.6469) + D(0.6926) + E(2.3779)$
$+ F = 0$

Using least sq. $A^TA\hat{x} = A^Tb$

2) a) $\Delta v = I_{sp}\, g_0 \ln\left(\frac{M_0}{M_0 - \dot{m}t}\right)$ [M_0 = initial mass of rocket]

$\Rightarrow v = I_{sp}\, g_0 \ln\left(\frac{M_0}{M_0 - \dot{m}t}\right)$ [Initial velocity = 0]

b) $t_b \rightarrow$ burnout time

~~Time travelled~~

Distance travelled before burnout time =

$$\int_0^{t_b} v\,dt = I_{sp}\, g_0 \int_0^{t_b} \ln\left(\frac{M_0}{M_0 - \dot{m}t}\right) dt$$

$$\Rightarrow x = I_{sp}\, g_0 \int_0^{t_b} \ln\left(\frac{M_0}{M_0 - \dot{m}t}\right) dt$$

Take $\ln\left(\frac{M_0}{M_0 - \dot{m}t}\right)$ as u.

$$\Rightarrow x = \frac{I_{sp}\, g_0 M_0}{\dot{m}}\left[1 - \ln\left(\frac{M_0}{M_0 - \dot{m}t_b}\right)\left(\frac{M_0 - \dot{m}t_b}{M_0}\right) - \left(\frac{M_0 - \dot{m}t_b}{M_0}\right)\right] \quad (1)$$

After t_b, distance travelled

$$v^2 - 0^2 = 2g_0 s$$

$$\Rightarrow S = \frac{I_{sp}^2 \left(\ln\left(\frac{M_0}{M_0 - \dot{m}t}\right)\right)^2 g_0}{2} \quad (2)$$

$\therefore$ Total distance = (1) + (2)

$$\frac{I_{sp}\, g_0 M_0}{\dot{m}}\left[1 - \ln\left(\frac{M_0}{M_0 - \dot{m}t_b}\right)\left(\frac{M_0 - \dot{m}t_b}{M_0}\right) - \left(\frac{M_0 - \dot{m}t_b}{M_0}\right)\right] + \frac{I_{sp}^2 \left(\ln\left(\frac{M_0}{M_0 - \dot{m}t}\right)\right)^2 g_0}{2}$$