1. (25%) A spacecraft is to fly by a comet whose radius is 2 km. The time of closest approach is $t_k$. At $t_k$ an estimate and variance-covariance are calculated of the spacecraft position. The estimate is calculated in a 2-D coordinate system in a plane that contains the center of the comet and the spacecraft at $t_k$, with the center of the comet at the origin of the coordinate system. The values for the nominal trajectory and estimate (in km) at $t_k$ in this 2-D coordinate, and the variance-covariance for the errors in $\hat{x}$ are

$$X^* = \begin{bmatrix} 4 \\ -1 \end{bmatrix}, \quad \hat{x} = \begin{bmatrix} -2 \\ -5 \end{bmatrix}, \quad P = \begin{bmatrix} 9 & 4.8 \\ 4.8 & 4 \end{bmatrix}.$$  

a. What is the correlation coefficient?

b. At closest approach, sketch the comet, the spacecraft’s estimated position, and the 3-σ probability ellipse.

c. Is the comet outside of the 3-σ probability ellipse?

2. (30%) Problem # 42, Ch. 4 of the text.

3. (24%) Problem # 43, Ch. 4 of the text, parts a and b.

4. (21%) Answer true or false

   a. In the general orbit determination problem the estimation error covariance matrix will be a realistic estimate of solution accuracy______

   b. The semimajor, semiminor, and intermediate axes of the probability ellipsoid lie along the principal axes ______

   c. A major advantage of the state noise compensation technique is that it provides an estimate of the unmodeled acceleration______
d. A major advantage of solution via orthogonal transformations is that accuracy is enhanced because only the H matrix and not $H^T H$ is operated on.

e. If two parameters are independent i.e., totally uncorrelated, removing one from the solution list will not affect the estimation error variance of the other.

f. For $m>n$ (where $m$ is the number of observations and $n$ is the number of state parameters), and assuming no a priori information, there must be $m$ independent observations for a solution to exist.

g. The minimum variance estimator only requires knowledge of the mean and variance-covariance of the observation errors.