Answer the following questions and explain all solutions. Write down all steps of each solution as a pseudo code or algorithm. Note that code is not an explanation.

**Problem 1. Image stitching**

For the given pair of keble images (Figure 1):

1. Manually mark appropriate number of matching points in the two images and compute the homography matrix $H$ between the two views. Show the matching image points used for this part. Instructions for plotting matches are included below. (5 points)

2. Use the set of matched points provided to you in prob1.mat matlab workspace to estimate homography $H$ automatically using RANSAC. Write down RANSAC algorithm, give the threshold used for deciding inlier vs outlier. Show the
matching image points provided to you initially and matching image points
that are RANSAC inliers. (10 points)

3. Stitch the two images together using the homography matrix computed
above. Display the resulting stitched image. (10 points)

(25 points)
The file prob1.mat has the detected Harris corners row-column positions in
variables r1 c1 for the first image; variables r2 c2 for the second image; and
the corresponding matched pairs in the variable matches. Use the function plot-
matches.m provided to you. e.g. plotmatches(im1,im2,[c1 r1],[c2 r2],matches')

Problem 2. Epipolar Geometry

Figure 2: Chapel Images

For the given pair of chapel images (Figure 2):

1. Manually mark appropriate number of matching points in the two images
and compute the Fundamental matrix F using 8 point Algorithm. Write
down 8 point algorithm, print F and show the matching points used for this
part. (7 points)

2. Use the set of matched points provided to you in prob2.mat matlab workspace
to estimate the fundamental matrix F automatically using RANSAC. Give
the threshold used for deciding inlier vs outlier. Print F. Show the point
matches provided to you initially and matched points that are RANSAC
inliers. (7 points)

3. Pick a set of 5 points well separated from each other in each image find and
display the corresponding epipolar line in the other image. Show this for
fundamental matrix F estimated in part 1 and part 2. (4 points)
4. Show how to compute cameras matrices corresponding to a pair of canonical cameras where one camera is at origin and has projection matrix as
\[ P1 = [I | \bar{0}] \] and other is rotated and translated with respect to it. Compute such a camera pair for the fundamental matrix computed in part 1 and part 2. (7 points)

The file prob2.mat has detected Harris corners row-column positions in variables \( r1 \ c1 \) for the first image; variables \( r2 \ c2 \) for the second image; and the corresponding matched pairs in the variable \( matches \). Use the function \texttt{plotmatches.m} provided to you. (e.g. \texttt{plotmatches(im1,im2,[c1 \ r1]',[c2 \ r2]',matches')}) (25 points)

**Problem 3. Multiview Reconstruction**

1. Give two examples of Homography i.e describe two camera and scene settings which result in homography between the two views. (Provide example images taken from such a setting or draw figures describing such settings) (5 points)

2. Prove that under pure translation motion of camera epipole lies at vanishing point of direction of the motion. (10 points)

3. Write a short discussion on how to resolve projective ambiguity in reconstruction from two views using additional cues. Describe those cues. (10 points)

**Problem 4. Tracking**

We have a linear dynamical system with states \( X_i \). \( X_i \) is a normal random variable with mean \( DX_{i-1} \) and covariance \( \Sigma_d \). At each step the measurement \( Y_i \) is drawn from a distribution with two gaussian components \( \mathcal{N}(MX_i, \Sigma_m) \) and \( \mathcal{N}(0, \Sigma_n) \). \( P(X_1) \) is gaussian.

1. Show that if \( P(X_{i-1}|Y_1, \ldots, Y_{i-1}) \) is a mixture of \( k \) Gaussians then \( P(X_i|Y_1, \ldots, Y_{i-1}) \) is also a mixture of \( k \) Gaussians. (5 points)

2. Show that if \( P(X_i|Y_1, \ldots, Y_{i-1}) \) is a mixture of \( k \) Gaussians and the measurements \( Y_i \) are drawn only from the first component \( \mathcal{N}(MX_i, \Sigma_m) \) then \( P(X_i|Y_1, \ldots, Y_i) \) is also a mixture of \( k \) Gaussians. (10 points)
3. Show that the posterior \( P(X|Y_1, \ldots, Y_i) \) is a mixture of gaussian with \( 2^i \) components. (5 points)

4. We can not use an exact representation of the posterior in this case there are too many components. Suggest a strategy to manage this problem. (5 points)