Image Acquisition:

a) Describe the acquired calibration object in brief.

The calibration object used in this exercise is a paper-based cube with a side length of 5 cm. Each face of the cube is covered with a uniform black-and-white checkerboard pattern to ensure the presence of well-defined, high-contrast feature points.
The image was captured with the camera positioned approximately 15 cm in front of the object.

b) Specify important technical information of the used camera (i.e. type, resolution, etc.)

The image was captured with a smartphone camera (iPhone 17 Pro). The main camera module is equipped with:
• a 48-megapixel sensor,
• 2.44 µm quad-pixel architecture,
• and a 24 mm equivalent focal length lens with an f/1.78 aperture.
These specifications provide high-resolution imagery and sufficient light sensitivity for accurate camera calibration.

Control point measurements:

a) How did you define the axes of the object coordinate system?

The object coordinate system was defined directly on the cube:

- The origin was set at the front-left-bottom corner.
- The x-axis points to the right along the front edge.
- The y-axis points along the right side of the cube (depth direction).
- The z-axis points upward.

Because each cube edge is exactly 5 cm, the 3D coordinates follow this geometry (e.g., (5,0,0), (5,5,5), etc.).

b) How precise were the object coordinates measured?

The object coordinates are based on the cube's known edge length (5 cm), so they are quite accurate.

In practice, the precision is limited by:

- manufacturing tolerance of the cube
- small rounding when using centimeter units
- slight perspective distortions in the camera image

Overall, the coordinates are accurate to about 1–2 mm, which is sufficient for camera calibration.

Interpretation of the projection matrix:

a.) Explain the geometric meaning of the extracted parameters in brief.

- The principal distance (~1077 px) represents the focal length of the camera in pixel units.
- The principal point (~492, 690) is where the optical axis intersects the image plane.
- The skew (~88.7°) shows that the camera sensor axes are almost perpendicular.
- The aspect ratio (~1.026) indicates that pixel width and height are nearly equal.
- The rotation matrix and angles (ω, φ, κ) describe how the camera is oriented relative to the cube (slightly above and to the right, looking downward).
- The camera center (~11.9, –7.1, 11.3 cm) gives the physical location of the camera in the cube's coordinate system.

b.) Evaluate the whole calibration process. How precise is the camera orientation determined and where does the quality depend on?

The calibration result is consistent and plausible:
the focal length, principal point, and orientation all match what we see in the image. The estimated camera position also agrees with the real setup.

The overall precision is reasonable for this type of small-scale calibration.
The accuracy mainly reflects how well the corner points can be located in the image and how well the cube geometry is known. With only six points and a simple pinhole model, small errors are expected, but the results are still reliable and geometrically meaningful.