One of the first things that amateur astronomers do with a camera is to point it at the North Celestial Pole (near Polaris the North Star) and take a time-exposure lasting minutes or hours. The Earth's rotation causes the stars to form long semi-circular trails.

Problem 1 - Which stars in the photo are nearest the NCP?

Problem 2 - The width of the image is 36.0 degrees. What is the scale of the image in arcminutes/millimeter?

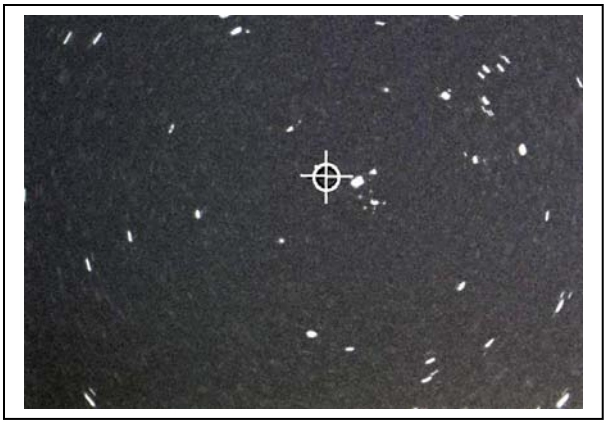
Problem 3 - Using your method of choice, identify the location of the NCP as accurately as possible.

Problem 4 - Which star do you think is Polaris in the photograph, and how far is it from your location for the NCP?

Problem 5 - What features in the photograph are not stars or planets? Explain your reasoning.

Problem 6 - From the information in the photograph, to the nearest minute of time, how long was the camera shutter left open to make this 'star trail' photograph?

Answer Key



Problem 1 - As Earth rotates, the stars will be trailed into arcs of circles that are exactly concentric with the North Celestial Pole. **Look for a region where the star arcs nearly vanish.** This region is in the lower left-hand corner of the picture, which is enlarged and shown on the left.

Problem 2 - The width of the picture is 160 mm, which corresponds to 36.0 degrees, so the scale is 0.225 degrees/mm. Since 1 degree = 60 arcminutes, this is equivalent to 0.225 x 60 = **13.5 arcminutes/mm.**

Problem 3 - Use a compass to place trial pivot points within the region, and test by matching the arc drawn by the compass with the arcs of several stars that are far from this region. **By trial and error, students should be able to get points that are close to the one indicated in the image by the circle and cross.**

Problem 4 - The bright star just to the right of the cross. **The distance is about 3 mm or 40 arcminutes (0.7 degrees).**

Problem 5 - What features in the photograph are not stars or planets? Explain your reasoning. Answer: **Stars and planets do not share Earth's rotation so they will leave arcs concentric with the NCP in the photograph. Objects on Earth, or in the camera, will remain in the same fixed spot in the picture because they are not moving.**

Problem 6 - From the information in the photograph, how long was the camera shutter left open to make this 'star trail' photograph? Answer: A full 360-degree arc would represent 24 hours. We need to measure the length of an arc in degrees, then determine how far it is from the NCP in degrees, and from the ratio of the arc length to the circumference of the complete circle we get the fraction of a 24-hour period that the trail represents. Selecting one star at random in the picture, like the bright one at the far-right edge of the picture (the star Delta Cassiopeia), it is located 133 mm from the NCP, and its arc is 6 mm long. This represents a radius of 29.9 degrees and a length of 1.35 degrees. The circumference is 2 x 3.141 x 29.9 = 187.8 degrees. The arc is the fraction 1.35/187.8 = 0.00719 of full circle or 24 hours x 0.00719 = 0.17 of an hour or **10 minutes.**