Camera Calibration and Mounting Recommendations

The procedure below allows obtaining the focal length of the camera. There are cameras that allow to set different resolutions and the focal length changes with different resolutions for some cameras. It is recommended that the focal length is obtained every time a new resolution is selected.

1. Mount the camera in the dashboard of the vehicle facing forward. The camera should be sufficiently high so that most of the scene in front of the vehicle will be captured. Several times the actual dashboard of the vehicle is captured as part of the scene. Depending on the camera size and mounting structure this is unavoidable. It is recommended that you change the camera's height if the scene is not properly captured rather than using the camera tilt angle to compensate.
2. Measure the camera height above the ground-plane which is the road. You can accomplish this by measuring first the distance between the center of the camera lens and the floor of the vehicle. Then you measure the distance between the floor of the vehicle and the road. It is recommended that you bring a tape measure to perform this and other measurements.
3. There are 3 positioning angles in all cameras: tilt, roll and pan. All three angles should be as close to zero as possible. It is recommended that you use a portable inclinometer to verify that the angles are actually close to zero once the camera is mounted. The inclinometer will only allow to verify that the tilt and roll angles are close to zero. The pan angle will be zero when the plane of the camera is parallel to the front axle of the vehicle. In this case it is recommended that to achieve this objective you align one of the horizontal borders of the camera as parallel as possible to the top border of the windshield. An alternate method is to draw over the pavement a line that is orthogonal to the front of the vehicle and verify through the camera recording that this line passes through the middle of the image frame (or as close as possible). If the roll angle is close to zero the orthogonal line we just mentioned will be recorded as a vertical line on the image frame.
4. For these cameras that support zooming we recommend to set auto-zoom to off. Similarly for these cameras that provide stability mechanisms we recommend to set auto-stability adjustment to off (otherwise the camera lens will be moving despite all the efforts made above to set the rotation angles to fixed positions).
5. Once the camera is set as mentioned above and the other settings are fixed (resolution) we can proceed to obtain the focal length. We recommend having the vehicle parked on a parking lot. You can use the white lines of the parking lot space where you parked your vehicle as support lines for this procedure in the way we will explain. For this purpose we recommend to park your vehicle so that both wheels on either side of the vehicle are at the same distance from the border of one of the white lines so that the vehicle is oriented parallel to the white lines on the parking box where the vehicle is.
6. Draw with chalk or some other means a horizontal line on the pavement in front of the vehicle at a distance of 8 meters away from the camera (this should guarantee that the line is visible to the camera beyond the hood of the vehicle). For this purpose you can use the white lines of the parking lot space as reference and extend these lines forward using the chalk while keeping

alignment to the white lines. Since you parked parallel to the white lines the lines your are drawing are parallel to the vehicle. At a distance of 8 meters away from the camera draw a line that is orthogonal to both line extensions you drew.

7. Turn-on the camera and record a video of the scene in front of the car.
8. After retrieving the video you recorded, extract any image frame from the video.
9. Measure the distance d in pixels between the center of the image-frame and the 2D representation of the horizontal line that you drew on the pavement.
10. For a real world distance of D of 8 meters you can obtain the focal length using the following equation:

$$f = \frac{Dd}{H}$$