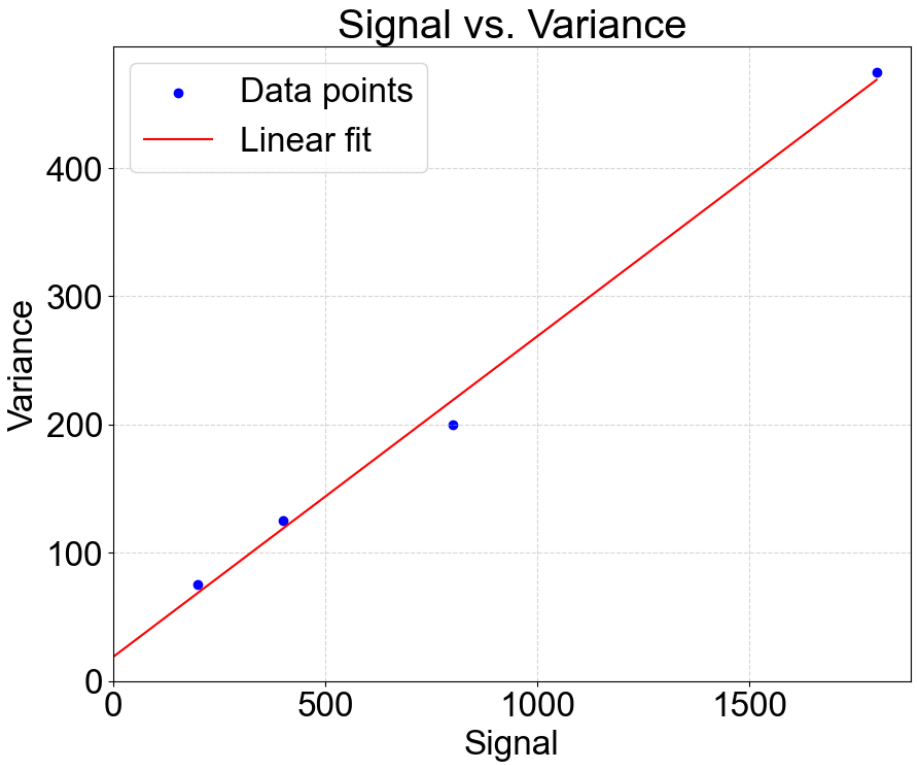
2. A sequence of flat-field observations is obtained at different exposure levels. The following signal and variance values were found: 200DN, 75; 400DN, 125; 800DN, 200; 1,800DN, 475.
Plot the data and derive the gain factor g (electrons/DN) and the readout noise R.



$$V_M = \frac{1}{g} S_M + \left(\frac{R}{g}\right)^2$$

g = 1/slope, R = g * sqrt(intercept)

slope = 0.25, intercept = 18.75

→ g = 4, R = 4 * sqrt(18.75) ~ 17.3

8. Describe the major steps needed to calibrate a high-resolution spectrograph with a CCD or IR array detector.

Identify Dispersion Direction: Determine if increasing pixel numbers correspond to increasing wavelength, setting up a clear understanding of how data is organized.

Interpolate Over Dead Pixels: Fill in data gaps caused by dead pixels or columns to avoid skewing analysis results. Keep a record of these locations since they do not contain actual data.

Flat-Field Calibration: Combine flat-field images, ensuring they are normalized. These images may be captured with the slit wide open, creating uniform CCD illumination using, for example, a quartz lamp against a white screen.

Apply Flat-Field Correction: Divide the observed stellar spectra by the flat-field image to correct for pixel-to-pixel sensitivity variations.

8. Describe the major steps needed to calibrate a high-resolution spectrograph with a CCD or IR array detector.

Order Identification: If using software like IRAF, manually identify spectral orders on the CCD, potentially using a brighter star if the target star is too faint. This allows the software to correctly locate and extract spectra.

Spectrum Extraction: Isolate rectangular sections of CCD data containing the stellar spectrum and arc lamp spectra, using routines like "apsum" in IRAF.

White-Light Spectrum Division: Divide the flat-fielded stellar spectra by the white-light spectrum acquired with the normal slit width. Ensure the white-light spectrum is itself flat-fielded to remove fringe effects, focusing on overall variations rather than pixel-specific corrections.

Wavelength Calibration: Identify emission lines from an arc lamp, typically a thorium-argon lamp, to establish an accurate pixel-to-wavelength transformation. This step is critical for precise wavelength measurements.