CALIFORNIA INSTITUTE OF TECHNOLOGY

ME/CS 132a, Winter 2011

Problem Set #1 Due: 18 Jan 11

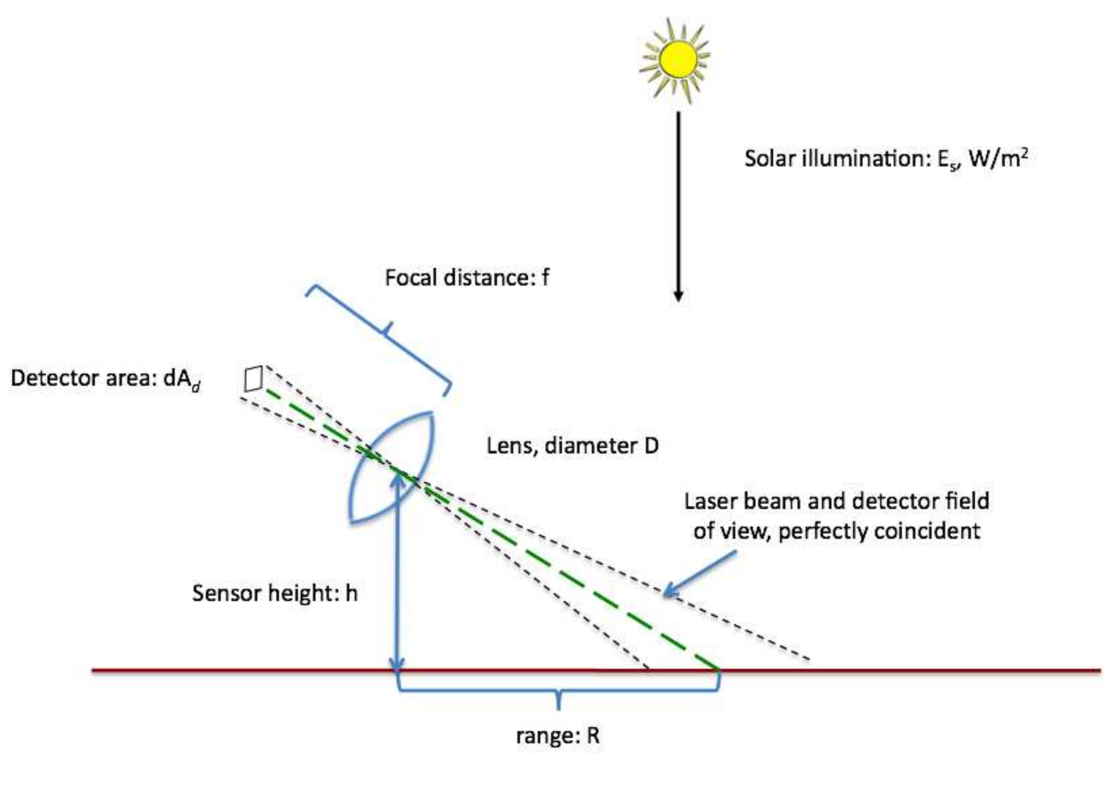
1. [10 points] The solar spectral irradiance at the surface of the Earth has approximately the following values in the center of the visible, MWIR, and LWIR bands, respectively:

   (a) 1 $W/m^2/nm$ at the wavelength of 500 nm
   (b) 10 $mW/m^2/nm$ at the wavelength of 4 μm
   (c) 0.1 $mW/m^2/nm$ at the wavelength of 10 μm

   Gain an appreciation for how this compares to thermal emission from the Earth's surface by computing the spectral radiant emittance from Planck's law at the same wavelengths, for a temperature of 300 K.

2. [15 points] Consider the following simplification of a real problem involving a Mars rover using a laser diode to sense the terrain ahead. Suppose the laser beam perfectly coincides with the field of view of a detector pixel (of area dA_d, located at the focal length f) as shown in the figure, and that the laser power is Φ_L (in W). Suppose the sun is directly overhead, with irradiance E_s (in W/m^2) in the spectral band of an optical filter in the sensor. Suppose that the terrain is a lambertian reflector with an absorption factor ρ (see the lecture notes for the definition). For simplicity, assume that the detector area dA_d, the lens area, and the illuminated patch on the terrain are all small enough.

   (a) How much laser power Φ_r (in W) is reflected back to the detector? Your answer should depend on the range R, the sensor height h, and/or the lookahead distance $L \triangleq \sqrt{R^2 + h^2}$.
   (b) What is the ratio of Φ_r to Φ_s, the in-band solar power reflected to the detector?



3. [10 points] Forsyth, Problem 1.4
4. [15 points] Forsyth, Problem 1.5