EECE7105— OPTICS FOR ENGINEERS— Fall 2025

Final Exam Rev. 1

Submit by email as a single .pdf file before Thursday 11 December, at 23:59:59.

1 Fourier Optics

Download the file fo.m. Modify the file to use a checkerboard object, checkerboard(128,4,4);.

Set the NA to 0.5. Also include a central obscuration which could be the pupil blockage by the secondary in a reflective telescope. Make the boundary of this obscuration have an NA of 0.05. Modify the last image to show the field rather than the squared field.

Explain qualitatively the pattern in the pupil and in the image. At a minimum, discuss symmetry and repetition in the pupil. In the image, discuss the mean of the image, compared to that of the object. and explain the field of the image.

2 Radiometry

Rooms on the upper floor of a building can become quite hot in the summer. Here we consider a possible solution.

Please download and unzip the black–body zip file on the course website.

You will find bbd.m, which is a useful calculator for black–body radiometric and photometric quantities. You will also find trapni.m which is for trapezoidal integration. Use it as

$$\texttt{E} = \texttt{trapni}(\texttt{Elambda}, \texttt{wavel});,$$

where $\texttt{Elambda} = E_\lambda$ is the integrand and $\texttt{wavel}$ is a vector of the variable of integration. Type

`help bbd`

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for instructions on using bbd.m.

Assume that the sun is a 5000K black body with an irradiance at the Earth's surface of $1000\mathrm{W/m}^2$ falling on the roof of our building. We will consider three different roof surfaces. The first is a perfect (black) absorber ($\epsilon = 1$), and the second is a rough white surface perfectly and diffusely reflecting throughout the UV and visible band into the near infrared ($\epsilon = 0$ for $\lambda \leq 2.5\mu$m) and perfectly absorbing or black for longer wavelengths ($\epsilon = 1$ for $\lambda > 2.5\mu$m). Note that it "appears" white to us viewing it in the visible spectrum, but it absorbs all infrared wavelengths beyond the cutoff.

The third surface addresses the fact that it is hard to make a perfectly white or black material. Let the high emissivity (and absorptivity) at wavelengths longer than cutoff be 98% and the low one at shorter wavelengths be 5%. That is, the material reflects 95% at wavelengths shorter than cutoff and 2% at wavelengths longer than cutoff.

Assume that the roof is at a temperature of $T = 30°$C.

Note: When I integrate from "zero" to "infinity" wavelength, I usually use limits of 0.1μm and 100μm.

a. Using bbd.m, what are the chromaticity coordinates, x and y of the sun? Do these make sense?

b. For the black roof, plot the spectral irradiance, $E_\lambda(\lambda)$ of the incident sunlight and, on the same plot, the spectral radiant exitance, $M_\lambda(\lambda)$ from the roof. Choose axes to illustrate the relative values of incident and emitted light. Logarithmic axes may be useful. At what wavelength do they cross?

c. For each roof, plot the spectral irradiance of the incident light and the spectral radiant exitance of the roof, and the net absorbed power per unit area. Calculate the absorbed sunlight irradiance and the emitted radiant exitance from the roof, and the net absorbed power per unit area. Will the temperature of each roof go up or down with time?

Note that we are neglecting conduction and convection. We are also neglecting the fact that the other side of the roof is probably maintained at a certain room temperature. If the net absorbed power is positive the roof will become hotter, adding to the heat of the room. If it is negative, the roof could actually cool the room. These effects would not be hard to include in our model, although I do not recommend you do so as part of the exam.