Undergraduate Radiometry
Extra Credit Assignment

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1 Introduction

All quarter we have been talking about radiometric calculations where we (more often than not) assume the source is an idealized *point source*. Earlier in the quarter we completed a lab that demonstrated that the inverse square law holds (very) true for point sources. What do we do when we can no longer use point source approximations? That is, what if the source is significantly large, relative to the distance from the detector? In this situation, we need to develop a new strategy for measuring the radiation from an *extended-area* source. An example of this may be calculating the irradiance onto a table top illuminated by a rectangular luminaire in the ceiling of a room. Below are a series of area source cases that should "illuminate" the subject matter. Your write up will contain the answers to the following questions. You may have to use additional software packages (*i.e,* MathCAD, etc.) to handle the numerical integrations. This is an exercise to help you solidify your understanding of how area source calculations are performed. In your write up, you should explain all steps so as to convince the grader you understand the subject matter. Be sure to state all assumptions. You should label figures and diagrams clearly in order to receive full credit.

1) Radiation from a Lambertian Disk *i)* Derive an equation that relates the temperature, T of a larger disk to the flux, Φ onto the second smaller disk, similar to that shown in Figure 1. Explain all steps in your derivation. State all assumptions. You should label figures and diagrams clearly in order to receive full credit. *ii)* Using your expression calculate how much power (i.e., flux) is transferred onto the smaller disk knowing that the larger disk is of diameter $6cm$ at a temperature of $400K$. The smaller disk is $10cm$ away and has a diameter of $0.2cm$ and is located as shown in Figure 1.

2) Radiation from a Lambertian Rectangle *i)* Derive an expression that relates the radiance, L_s from a rectangular source to the irradiance, E onto a detector directly below the center of the source (see Figure 2(a)). Explain all steps in your derivation. State all assumptions. You should label figures and diagrams clearly in order to receive full credit. *ii)* Use this derived expression to calculate the irradiance onto a detector given that the rectangular source is a $0.5m \times 1.0m$ diffuse illumination panel in the ceiling illuminating a centered target immediately below it at a distance of $1.5m$, as can be seen in Figure 2(a). The source has a uniform radiance of 3×10^{-5} $[Wcm^{-2}sr^{-1}]$. *iii)* Additionally, derive and calculate an expression for the case when the detector is located at a *corner* below the source, as seen in Figure 2(b). Are there any differences in the calculations? Should there be? Explain. You may need additional software to perform the numerical integration (*i.e,* MathCAD, etc.).

3) Radiation Incorporating Two Finite Parallel Rectangles *i)* Derive an equation for the irradiance onto a finite sized receiver from a finite sized source (as seen in Figure 3). This derivation is very similar to question 2. This equation should relate the irradiance onto the receiver to the source (of radiance L_s). Explain all steps in your derivation. State all assumptions. You should label figures and diagrams clearly in order to receive full credit. *ii)* Then, using the values from question 2, calculate the irradiance onto the surface from the source (assuming the detector plane is the same size as the source plane). You may need additional software to perform the numerical integration (*i.e,* MathCAD, etc.).

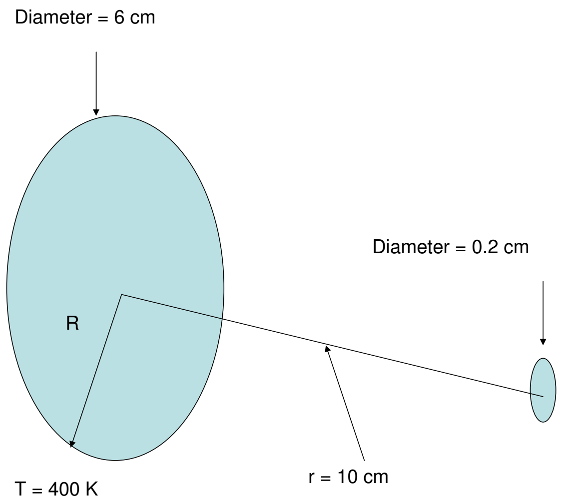
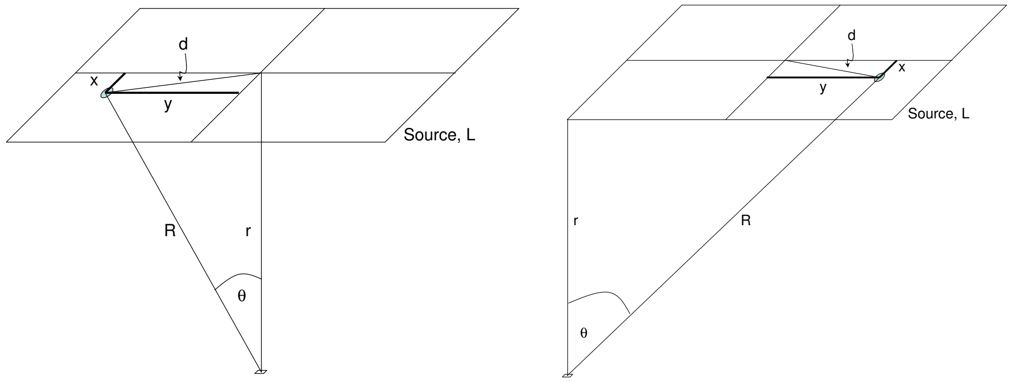


Figure 1: Geometry for radiation from a lambertion disk onto a finite sized surface.



(a) (b)

Figure 2: Geometry for rectangular lambertion source and detector located directly below the source (a) in the center and (b) at one corner.

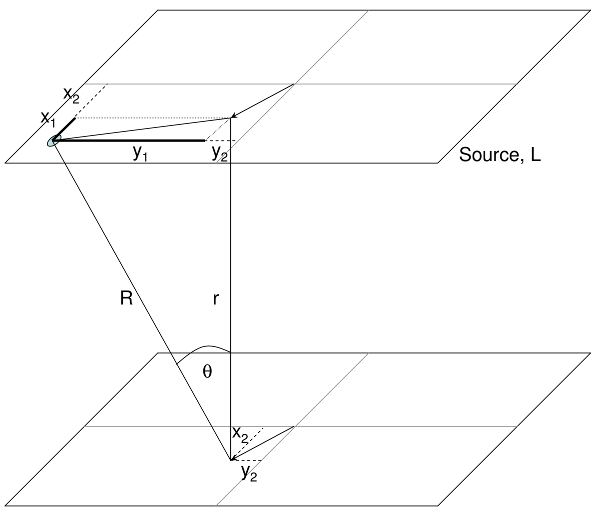


Figure 3: Geometry for two finite parallel rectangles.