

## **Subsystem Analysis [Individual assignment]**

Description of *specific components* (subsystems) of larger team design

**Introduction** – pls write a common introduction for the whole team

*Describes* team's design

*Details* how design was subdivided

*Explains* relationship between other subsystems and this subsystem  
(not common)

### **Body of Report**

Technical Specifications

Detail technical aspects of design (dimensions, for example)

Refer to attached graphics

Number and cite them *in order*

### **Meeting Requirements**

Demonstrate *how* component *complies* with

Client request

Industry standards (as appropriate)

Safety/environmental standards (as appropriate)

### **Assembly and Operation**

Describe how component is assembled

Describe how subsystem operates

Refer to attached graphics

Minimum 4 views (3 orthographic, 1 isometric, for example)

Drawn with SolidWorks

## **Back Matter**

### **References**

Include all references used

IEEE style (see GWE)

Websites

Are specific to page you are citing (not mfr's home page)

Include author (if possible) and date accessed

### **Graphics**

Labeled (caption below for figures; title above for tables)

If landscape, bottom at right of page

### **Format**

Memo format

Audience = mentor

3-5 pages, 3-4 pages of text + graphics, tables

(See GWE or Student Guide for more information)

Memorandum for: Deanna Young, Project Manager  
From: Matt Young, Handyman Extraordinaire  
Subject: Interior lighting of living room: illumination subsystem  
Date: March 13, 2004

The purpose of this memo is to describe the illumination subsystem for the living room at 1000 Pitchblack Road in Boulder. Specifically, I will describe how I will ensure that the illumination is adequate for reading at one of several workstations (easy chairs).

**Problem statement.** [From project plan. The following is common to every subsystem analysis memo.] The problem is to replace the lighting system in the living room, an area of approximately 18 x 15 feet. The living room houses a small couch, 4 rocking chairs, an antique carpenter's chest, and an assortment of sideboards such as an antique dry sink. The lighting is to be

as efficient as possible and  
white, that is, a color temperature of 2700 K or more

In addition, there are constraints:

a single, central ceiling light is prohibited,  
glare must be minimized,  
old color photographs on walls must be protected from short-wavelength light,  
and  
the cost must be less than \$200

[From letter of understanding, updating information in clarification memo.] I understand that two individuals will have to read at one time, but the room will have to be lit well enough for a dozen or more to engage in conversation without directly viewing a bare bulb, and that you plan to rearrange the furniture in the room constantly (Figure 1).

[In your reports, use "we" as appropriate; there is only one of me.] I have divided the project into several subsystems: luminaires (lampshades), ambient lighting, and task lighting. These are three discrete tasks that do not overlap one another very much, and the two lighting tasks require somewhat different calculations. The task-lighting subsystem ensures that the illumination at one of the workstations is adequate for reading.

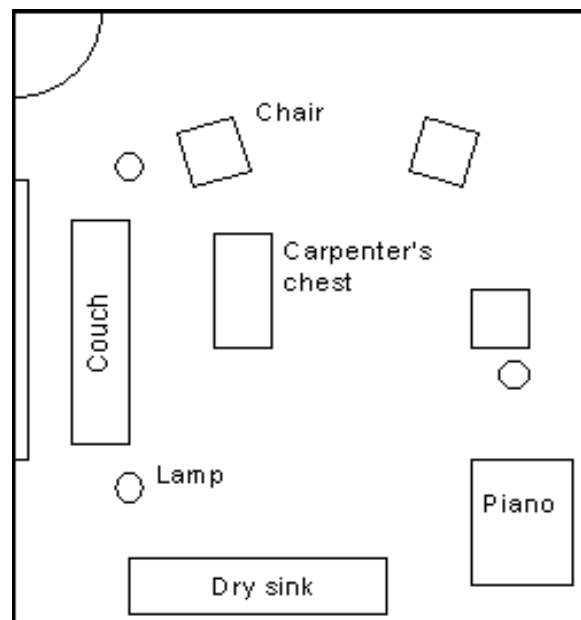


Figure 1. Floor plan, showing locations of lamps (circles) with respect to chairs(squares) and other furnishings.

[From LOU but updated.] As you know, I have considered task lighting that uses incandescent bulbs, compact fluorescent bulbs, low-pressure sodium lamps in reflecting fixtures, and quartz-halogen bulbs, which are best used in track lighting. Low-pressure sodium lamps are the most efficient, but I have ruled them out because of their color. [Common part of report ends roughly here.] In my last memo, I detailed my choice of compact fluorescent lamps. Remember, though, my caution that the photographs should never be exposed directly to a compact fluorescent bulb.

**Illuminance.** The purpose of this subsystem is to ensure that the *illuminance*, or intensity, at any one of the workstations is adequate for reading. Illuminance is a measure of the brightness of the light incident on a plane and is measured in lumens per square meter ( $\text{lm}/\text{m}^2$ ), or lux (lx) [1]. An illuminance of 500 lx is required for good reading [2].

According to measurements I have made in my own living room, a typical floor lamp stands about 125 cm above the floor; that is, the bulb is that distance above the floor. A book held at a comfortable reading distance from the eye is no less than 85 cm above the floor. Therefore, the bulb will be no more than 40 cm from the reading material.

A certain 20-W compact fluorescent bulb emits 1150 lm of visible light [3]. We need to calculate the illuminance at a distance of 40 cm from the bulb.

The area of a sphere whose radius is  $R$  is  $4\pi R^2$ . [No, you don't have to reference such common knowledge.] Thus, the illuminance  $E$  on such a sphere is

$$E = \frac{\phi}{4\pi R^2} \quad , \quad (1)$$

where  $\phi$  is the *luminous power* emitted by the bulb [1]. If we set  $\phi = 1150 \text{ lm}$  and  $R = 40 \text{ cm}$  (Figure 2), we find that  $E = 570 \text{ lx}$ . In addition, if we place the bulb in a white or off-white shade, we may estimate that the illuminance increases perhaps 30 % owing to the diffuse reflectance from the shade. Thus,  $E$  increases to approximately 750 lx, for a safety factor of 50 %. [You could also look up luminaire in a lighting book or a technical encyclopedia.]

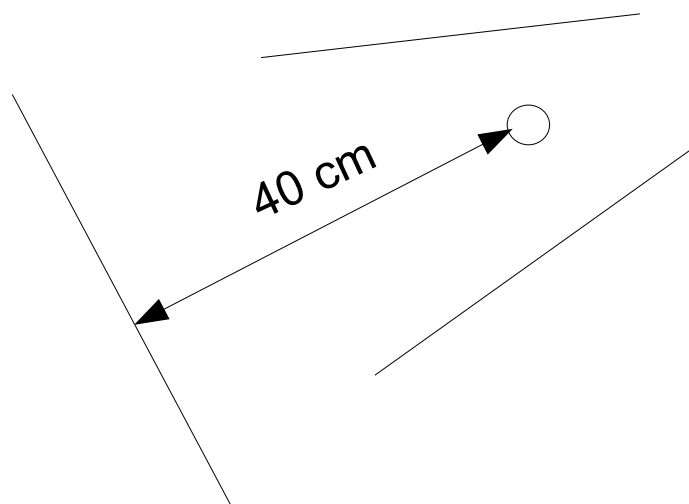


Figure 2. Schematic drawing of a compact fluorescent bulb in a reflecting shade and showing the distance to the work surface.

**Color.** The color of a light source is described by its color-rendering index (CRI) [4]. CRI measures the ability of a source to render colors accurately, where, for our purpose, “accurately” means by comparison with a 5000-K blackbody. A 60-W incandescent bulb, even though its color temperature is only 3000 K, has a CRI very nearly 1. Fluorescent bulbs have CRI’s between 60 and 85, depending on the phosphors used in the bulb. Unfortunately, the GE bulb does not specify either CRI or the designation, warm white, cool white, or daylight. Osram-Sylvania, however, provides such data, and its compact fluorescent lamp CF20EL-8-30MED is a 20-W bulb with a CRI of 82 and a color temperature of 3000 K [5]. In the final report, I will therefore recommend that bulb or a similar bulb. [Your analyses will probably be longer than this sample and should include a decision matrix such as that in my project plan.]

**Cost.** The 20-W compact fluorescent bulb will cost between \$4 and \$10, depending whether you can find it on sale. A white, diffusely reflecting lampshade can cost anywhere from \$10 to \$∞. If we assume \$25 for each of 3 lampshades and \$5 for each of 3 CF bulbs, then the total cost is \$90, as detailed in Table 1. Labor costs are excluded.

Table 1. Cost of lighting system (labor not included). [Note formatting of table.]

Item	Unit cost (\$)	Number	Subtotal (\$)
Lampshade	25	3 ea.	75
CF bulb	5	3 ea.	15
<b>Total</b>			<b>90</b>

I am confident that you will find the bulbs more than satisfactory, and I cannot tell you how much I am looking forward to another 40 years of dishwashing. If you have any further concerns, please contact me by e-mail at [mmyoung@mines.edu](mailto:mmyoung@mines.edu).

**References.** [You will need 6-10 technical references, not the 5 shown here.]

[1] Matt Young, *Optics and Lasers*, 5th ed., Berlin, Heidelberg, New York: Springer-Verlag, 2000, Chap. 4.

[2] Untitled, [www.rehab.queensu.ca/mclean/Lecture9.pdf](http://www.rehab.queensu.ca/mclean/Lecture9.pdf), accessed 13 March 2004.

[3] Packaging information, General Electric Standard Compact Electronic Bulb, Cat. No. FLE20TBX/2/SPX27.

[4] Graeme Lister, “Keeping the Lights Burning: The Drive for Energy Efficient Lighting,” *Optics and Photonics News*, January 2004, pp. 20-25.

[5] “Osram-Sylvania: The Leader in Energy-Saving Fluorescent Lamps,” [www.sylvania.com/catalog/pdfs/cat\\_89\\_132\\_fluo.pdf](http://www.sylvania.com/catalog/pdfs/cat_89_132_fluo.pdf), accessed 13 March 2004.

Updated 10/23/06.