QUIZ
Fundamentals of Daylighting – 1 h30’

Questions  20 pts

5 pts  a. How can you interpret the V(λ) curve from the visual perception point of view?

2 pt  b. What is the relation between the transmission, absorption and reflection coefficients of a surface when hit by light? Can any of them be nil? Can any of them be 100%?

4 pts  c. What is the relation between exitance and illuminance for an arbitrary surface of reflection coefficient ρ? How can you determine ρ if the surface is diffuse and all you have is a luxmeter and a luminance-meter?

3 pts  d. From the CIE chromaticity diagram given on the next page, determine the chromatic coordinates [x, y, z] of a black body emitting at 2000 °K and 6500 °K. What is the wavelength of the dominant color they correspond to?

4 pts  e. Why is solar time different from legal time [time indicated by our watches]?

2 pts  f. The respective contribution of the different heat transfer modes occurring for a double glazing comprising two clear glass panes separated by air is analyzed. One finds out that 30% of the total heat transfer is due to conduction, 6% to convection and 64% to radiation. To improve its insulating properties, what would you suggest between creating vacuum between the glass panes and adding a selective coating that would reduce the radiation by a factor 8?
Problems 30 pts

I. The individual reading spaces of the Phillips Exeter Academy Library, located in Exeter (New Hampshire) and designed by Louis Kahn in 1967-1970, are positioned along the periphery of the building, and are separated from the large central atrium by the rows of book shelves. In addition to the diffuse light brought in by the large superior windows, each reading cell benefits from direct sunlight through a small lateral window positioned at desk height and equipped with a sliding wood blind. All four façades have been treated equally as far as solar protections are concerned.

Direct sunlight should be avoided on the work space at anytime.

On the plane and section views of individual reading cells given below, determine the limit angles $\alpha_1$, $\alpha_2$, and $\beta_1$ for solar penetration and report the angles on the provided tracing paper over the shadow protractor given on the next page, by shading the areas corresponding to sun directions for which the lower windows always benefit from total protection.
Superpose the projected shadows on the stereographical view below (which corresponds to the latitude 42°22'N of Exeter) for the four façade orientations.

5 pts Analyze the solar penetration occurrences over the year for each façade orientation.

2 pts What are the critical issues of choosing to have no solar protection for the upper windows?

1 pt What are the critical issues of having sliding wooden blinds for the lower windows as sole shading system?
II. In one of the exposition halls of the Kimbell Art Museum, located in Fortworth (Texas) and designed by Louis Kahn in 1972, you are making measurements by the zenithal opening as well as below one of the halogen sources; you dispose of both a luxmeter and a radiometer.

On your luxmeter, you get the following reading by the zenithal opening:

which is expressed in klux.

Exactly below the halogen source (considered a point source) and holding your luxmeter horizontally, you get the following reading, in lux:

Now taking your radiometer, you check the energetic illuminance by the zenithal opening and get the following reading, in W/m²:

Finally, because of annoying visitors, you cannot get exactly below the halogen source anymore with your radiometer and therefore decide to hold it horizontally 2m below the halogen source but at 45° off the vertical from the source. The reading you get is the following, in W/m²:
What luminous efficiency do you deduce from your measurements for natural light, and what is its unit?

What luminous efficiency do you deduce from your measurements for the halogen source?

What is the maximal luminous efficiency one can obtain with a source and what are the characteristics of this source?

What are the critical issues of using zenithal natural light for a museum and of using artificial light?

III. The architectural space of the church of the Convent of La Tourette is characterized by narrow lateral and zenithal openings, actively taking part in the dynamic and richness of the luminous ambiances inside the church. These openings are of small area and of strong luminosity compared to the opaque parts of the envelope.

On a sunny morning, you come in with a luminance-meter to take measurements from two different points of view on either side of the seating rows and want to make statements about the visual comfort of the visitors and pilgrims.

When you sit on the left hand side (point A on the illustration given on the next page), you measure luminances of 50, 3200 and 400 Cd/m² coming from the left, middle and right portions of your visual field respectively (Lₕ, Lₗ, Lₘ on the drawing). When you sit on the right hand side, you measure 100 Cd/m² from the middle (Lₗ) and 2900 Cd/m² from the right (Lₘ).
What contrasts (luminance ratios) do you perceive and are they acceptable for visual comfort recommendations?

Calculate what these contrast values would become if the walls were painted in white ($\rho = 0.7$) rather than being bare concrete ($\rho = 0.3$).