UNIVERSITÀ DEGLI STUDI DI BRESCIA

Exercise 1

a) Define the following radiometric quantities and write explicitly their units of measurement:
   - radiance,
   - irradiance,
   - radiant exitance.

b) Write the formula for the spectral radiance of the black body as a function of the wavelength and explain its meaning.

c) Starting from the definitions of emissivity and brightness temperature explain how the thermal radiation of any object can be described.

d) Starting from the result of point b) obtain the formula of the spectral radiance of the black body as a function of the frequency.

e) Starting from the result of point b) obtain an approximate formula for the wavelength of maximum spectral radiance; comment this result.

f) Plot qualitatively the spectral radiance of the black body for the following 3 temperatures: 0 °C, 25 °C, 6000 °C.

$$L_\lambda = \frac{2hc^2}{\lambda^5} \frac{1}{\exp\left(\frac{hc}{\lambda k_B T}\right) - 1} = 2hc^2 \lambda^{-5} \left(\exp \frac{hc}{\lambda k_B T} - 1\right)^{-1}$$

$$\frac{hc}{kT} \lambda^{-1}$$

Exercise 2

a) Describe a simple aerial photographic system based on a single lens camera.

b) Define the resolution of a photographic film and, in the case of a single lens camera placed on a satellite, derive a formula for the film limited resolution on the ground.

c) Explain how the resolution of a single lens camera is limited by diffraction and obtain a formula for the diffraction limited resolution on the ground.

d) Let us consider a camera on board of the GEOSAT-2 satellite at an altitude of 620 km; the film has a resolution of 120 lp/mm, the lens has a diameter of 40 cm and a focal length of 5 m: is the ground resolution of the photos taken by the camera in the visible wavelength range limited by diffraction or by the film resolution? Justify the answer.

$$s = \frac{\delta x_g}{\delta x_f} \qquad \delta x_g = \frac{\delta x}{s} = \frac{H}{f}\delta x$$

$$\frac{lp}{mm} \cdot \frac{10^3 mm}{1 m}$$

$$\delta x_g = \frac{1}{25}$$

Exercise 3

a) Describe the structure of the atmosphere and specify where airplanes and satellites can fly.

b) Explain the law of gravitation.

c) Briefly explain the three Kepler's laws.

d) By assuming a circular satellite orbit and starting from the basic laws of mechanics:
- obtain a formula for the satellite orbital velocity as a function of its altitude;
- obtain a formula for the satellite period as a function of its altitude.