Exercise 1

a) Write the formula for the spectral radiance of the black body as a function of the wavelength. Write explicitly the unit of measurement of that formula. Explain why that formula is important in the field of remote sensing.

b) Write the Stefan's law and explain its meaning.

c) Write the Wien's law and plot qualitatively the spectral radiance of the black body for a temperature of 30 °C and for a temperature of 5000 °C.

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

Exercise 2

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

b) Explain the law of gravitation and the general features of satellite orbits.

c) 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.

d) Starting from the results of point c) calculate the periods of two realistic satellite orbits (universal gravitational constant $G=6.67\times10^{-11}$ $m^3kg^{-1}s^{-2}$, Earth's mass $M=5.974\times10^{24}$ kg, Earth's radius R=6371 km).

Exercise 3

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) Explain how the wavelength of maximum radiance depends on the body temperature.

d) Starting from the result of point b), derive the Rayleigh-Jeans formula and explain when and why it can be useful.

e) Define emissivity and brightness temperature of a body and explain the importance of these parameters.

Exercise 4

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

b) Briefly explain the structure of a photographic film and explain the meaning and importance of the following parameters:
- speed,
- resolution.

c) Define the f/number of a lens and explain why this parameter is important in photographic system.

d) Explain how the resolution of a photographic system is limited by the resolution of the film and derive a formula for the film limited spatial resolution on the ground.

e) Explain how the resolution of a photographic system is limited by diffraction (assume that there is a single lens) and obtain a formula for the diffraction limited resolution on the ground.

Exercise 5

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) Plot qualitatively the spectral radiance of the black body for a temperature of 0 °C and for a temperature of 10000 °C.

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 radiance; comment this result.

Exercise 6

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

b) Briefly describe the structure of a photographic film and explain the meaning and importance of the following parameters:
- speed,
- resolution.

c) Define the f/number of a lens and explain why this parameter is important in a photographic system.

d) Explain how the resolution of a photographic system is limited by the resolution of the film and derive a formula for the film limited spatial resolution on the ground.

e) Explain how the resolution of a photographic system is limited by diffraction and obtain a formula for the diffraction limited resolution on the ground.

f) Let us assume that the camera is flying at an altitude of 10 km, the film has a resolution of 200 lp/mm, the lens has a diameter of 5 cm and a focal length of 150 mm: 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.