Problem 1
A laser beam is characterized by its power $P = 10^{11}$ W, and maximal irradiance $I_0 = 10^{15}$ W/m^2. The wavelength is $\lambda = 1\mu$m.

A) calculate the waist "area" A of the beam

B) calculate the Rayleigh range z_R

C) calculate the profile of the on-axis intensity $I(z)$ as function of the distance z from the beam waist. Sketch your result in a graph, clearly marking important features and the length scale.

D) what is the Full Width at Half Maximum (FWHM) of intensity diameter of the beam? Express it in terms of the $1/e^2$-radius of the intensity profile.

so w_0 is about 85% of FWHM.

E) Where (at what z) is the phase front of the beam planar? Where does the phase front have maximal curvature (minimal radius)?

Problem 2
A laser beam has power $P = 3$ W, and the wavelength is $\lambda = 1\mu$m.

A) Calculate the photon flux N (photons per second)

B) Calculate the force exerted by the beam if it is completely absorbed.

C) Calculate the force when the beam completely reflects at normal incidence

D) What is the force if the beam reflects (completely) from a mirror at an angle $\alpha = 45$deg?

E) What is the force at 45 degrees, if one half of the beam power is absorbed in a "lossy" mirror?

Problem 3

Estimate the force F Sun's radiation exerts on Earth. For simplicity, assume that all radiation that reaches Earth is absorbed. Sun's radiative power is $P = 4 \times 10^{26}$ W, distance from Earth is $D = 1.5 \times 10^{11}$ m, and Earth's mean radius is $R = 6.3 \times 10^{3}$ km.

A) Derive the formula for F from the classical radiation pressure expression, and evaluate.

B) Derive F from the quantum point of view, assuming that all Sun's radiation is emitted at a single wavelength, and that all photons are absorbed.