Please complete the following problems in the examination booklet provided. Show all your work. You will be graded more on correct method than correct answer. If you take an equation from the Hecht text, please give the equation number and page number.

Aids allowed: A pocket calculator with no communication ability. "Optics" 4th Edition (Copyright 2002) by Eugene Hecht.

Possibly helpful information:
　　The diameter of the Sun is $D_\odot = 1.4 \times 10^6$ km
　　The distance from Earth to the Sun is 1 A.U. $= 1.5 \times 10^8$ km

You may not communicate with anyone other than the invigilator during the test.

[40 points total for the test]

1. A child who lives near an ant-hill has a magnifying glass. The glass is circular with a diameter of 10.0 cm, and both sides of the glass are convex. One side has a radius of curvature of 150 cm, and the other side has a radius of curvature of 85 cm.   The index of refraction of the glass is 1.52.
    a. What is the focal length of this magnifying glass? **[6 points]**
    b. The child uses the magnifying glass to focus an image of the Sun on the ground. What is the diameter of the image of the Sun on the ground? **[4 points]**

2. A parallel beam of white light is refracted by a 60° glass prism in a position of minimum deviation. What is the angular separation of emerging red ($n = 1.525$) and blue ($n = 1.535$) light? **[8 points]**

3. The Hobby-Eberly Telescope in West Texas has a mirror with an 9.2 m diameter. Its surface is concave and spherical with a radius of curvature of 26 m. Light from a distant star is focused onto the tip of an optical fibre located at the primary focus.

    a. The core of the fibre has an index of refraction of 1.620. What is the maximum index of refraction of the cladding such that all the light reflected from the primary mirror is accepted into the fibre? **[8 points]**
    b. For visible wavelengths, the attenuation coefficient of the fibre is 0.85 dB/km. The fibre is 50 m long, reaching from the primary focus down to the spectrograph room in the basement. What percentage of the starlight entering the top of the fibre emerges from the bottom end? **[4 points]**

4. A child who lives near the airport has a green laser pointer, with a wavelength of 532 nm and an initial beam diameter of 4.0 mm. This naughty child shines the laser up at an aircraft that is coming in for a landing. The airplane is 500 m above the child, and the system is diffraction limited, meaning it is the narrowest possible beam.
    a. What is the diameter of the beam when it reaches the airplane? **[6 points]**
    b. The child's laser is a Class 2 laser with a power of 0.7 mW. Estimate the irradiance at the position of the airplane. **[4 points]**