University of California, Berkeley Physics

H7C Fall 2008 MidTerm Exam II
Optics

Maximum score: 100 points

1. (25 points)

For a thin lens, we know one of the light ray will be refracted as shown in Fig. 1. Here point A is at 30 cm to the left of the lens and point b is at 50 cm to the right of the lens.

a) (10 points) Determine the focal length of the lens.

b) (10 points) If an erected object P of height 10cm is put at position 60 cm to the left of the lens, what will be the position and the height of its image? Draw the ray diagram.

c) (5 points) If we put an opaque screen to block the lower half of the lens, describe what will happen to the image.

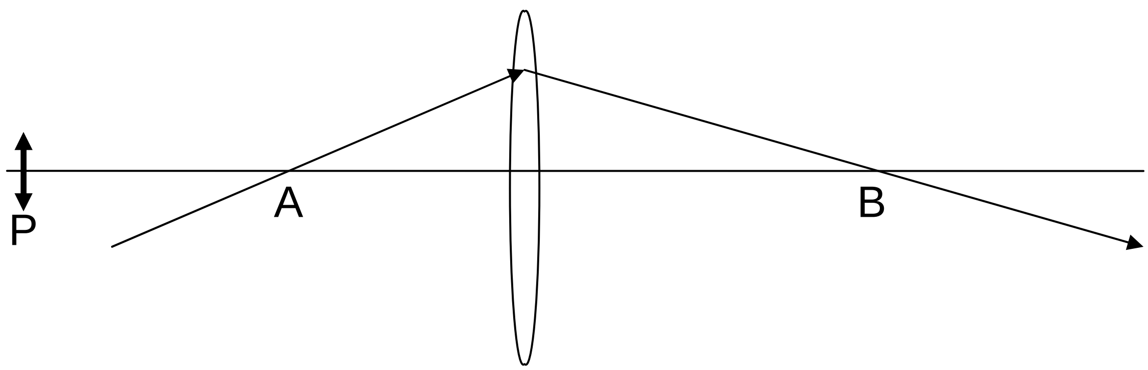

Fig. 1.

2. (15 points) A thin lens of diameter of 2 cm and focal length of 10 cm is used to focus parallel 532nm laser light to a point. The incident light has an intensity of 1mW/cm^2 and a beam diameter of 1 cm.

a) (5 points) What is the diffraction limited light spot at the focus?

b) (5 points) What is the laser intensity at the focal point?

c) (5 points) List two ways to increase the light intensity at the focal point without increasing the total incident laser power?

3. (25 points) Reflection grating is widely used in optical spectroscopy. Consider one such grating, depicted in Fig. 2. The light is diffracted from the slanted surface of each unit and the diffracted beam from these units will interfere with each other. The slanted

surface has an angle of 15 degree with respect to the horizontal plane, and the length of b is 500 nm. An incident laser beam of wavelength λ is directed normal to the grating (perpendicular to the horizontal plane). Denote by θ the angle that a particular outgoing ray of light makes with the vertical plane.

a) (10 points) Consider the diffraction from the slanted surface of a single unit, say the surface S. At what angle θ will the diffraction maximum lie?

b) (10 points) Consider the interference between different units, for what values of θ will the light leaving different units interfere constructively?

c) (5 points) For efficient diffraction of the light, the reflection grating is usually constructed so that the single unit diffraction maximum overlaps with the first order constructive interference direction for designed wavelength. If this is the case, what wavelength is our grating designed for?

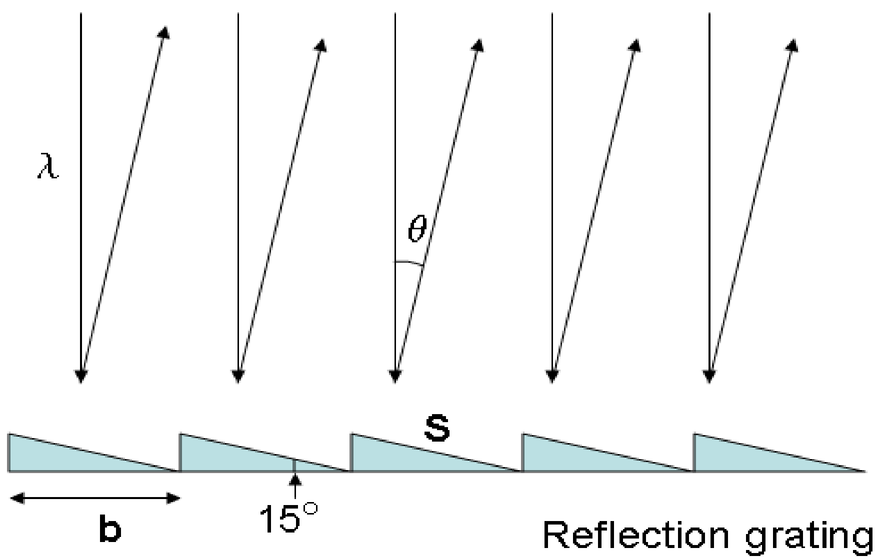

Fig. 2

4. (35 points)

The Michelson interferometer depicted in Fig. 3a has a birefringent plate in one arm. The birefringent plate has a thickness of 20 μm and refractive index difference between the high and low refractive index direction is 0.01.

A beam of y-polarized light with wavelength of 800 nm is incident on the Michelson interferometer. Initially, the high-refractive-index direction of the birefringent plate is along the y-direction and an interference pattern shown in Fig. 2b is generated at the screen. The initial intensity of the light at the center is I_0. Points A, B, and C denote the interference first maximum, first minimum, and second maximum in the pattern, respectively.

In terms of I_0, what will be the light intensity at positions A, B, and C under the following conditions? Give your reasoning.

a) (10 points) The birefringent plate is rotated by 45 degrees from its original position.

b) (5 points) The birefringent plate is rotated by 90 degrees from its original position.

Now the wavelength of the light is changed to 400 nm. Again in terms of I_0, what will be the light intensity at positions A, B, and C under the following conditions? Give your reasoning.

c) (10 points) The birefringent plate is returned to its original position (high refractive index direction along y direction).

d) (5 points) The birefringent plate is rotated by 45 degrees from its original position.

e) (5 points) The birefringent plate is rotated by 90 degrees from its original position.

(First determine what kind of waveplate the birefringent material is for 800nm and 400 nm light, respectively).

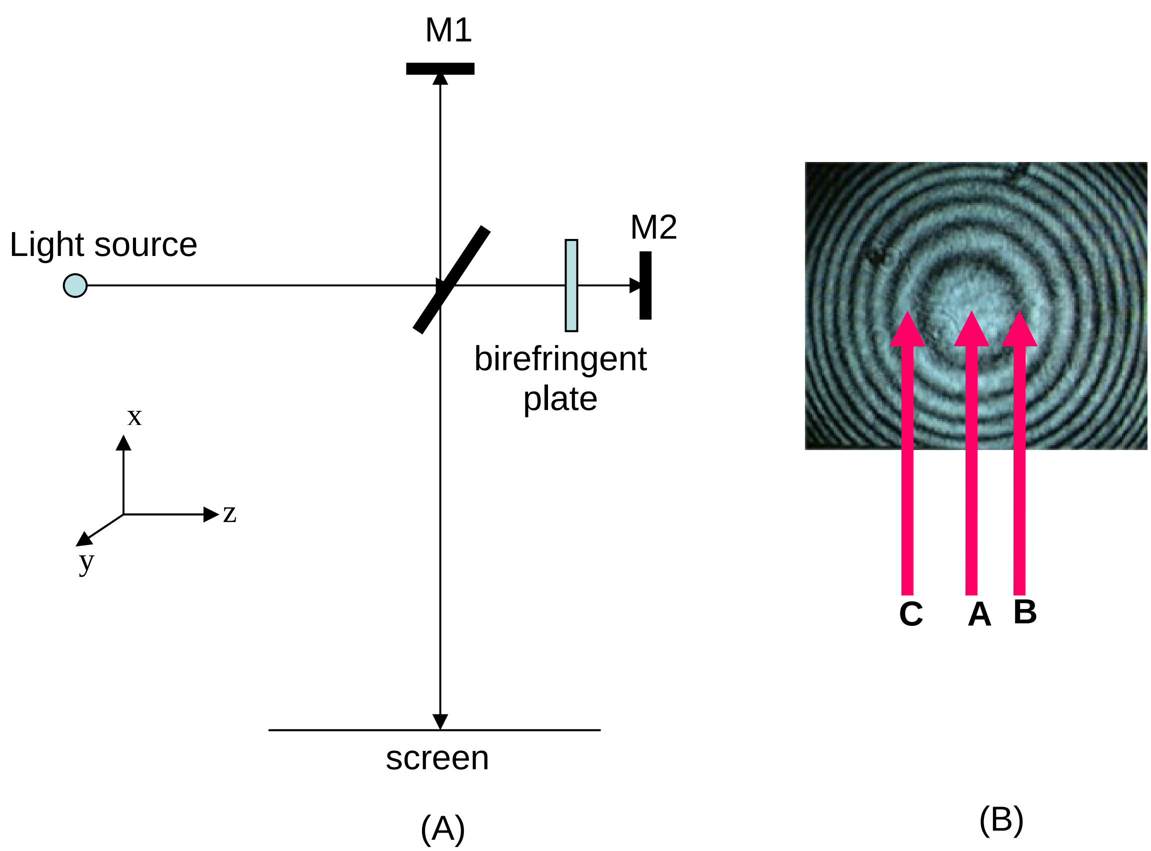

Fig. 3