Ministry of Higher Education & Scientific Research
University of Technology
Laser & Optoelectronic Eng. Department
Branch: Laser Engineering
Class: 1st Year:
Subject: University physics

Final Examination
Time: 3 hours
Date 2016
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Code:
Academic Year 2015-2016

Attempt only (Five) questions

Q1.a) State the three laws of reflection and refraction.

b) A ray of light passing two materials, material (a) is water and material (b) is a glass with index of refraction (1.52). If the incident ray makes an angle of (60^0) with the normal, find the directions of the reflected and refracted rays.

Q2.a) The wavelength of the green light from a laser is (532) nm in air but (450) nm in a liquid. Calculate the index of refraction of the liquid, and the speed and frequency of the light in this liquid.

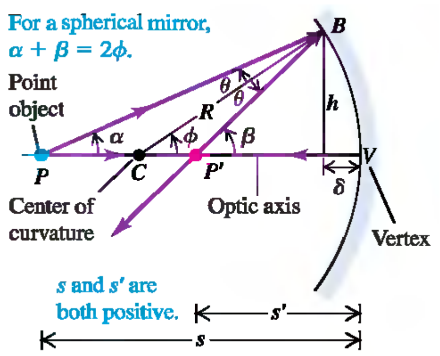
b) State Malus law, explain it briefly.

Q3.a) Explain the phenomena of total internal reflection, write down the equation of the critical angle, also draw a diagram showing it.

b) Consider glass with index of refraction n = 1.52. If light propagating within this glass encounters a glass-air interface, find the critical angle of refraction.

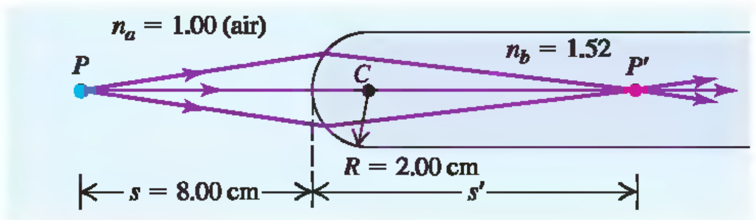
Q4. a) For spherical mirror below, Derive the object- image relationship:

$1/s + 1/s' = 2/R$



b) write down the lateral magnification equation of a spherical mirror.

Q5. A cylindrical glass rod in air (see Figure below) has index of refraction 1.52. One end is ground to a hemispherical surface with radius R = 200 cm.



أقلب الصفحة رجاء"

(a) Find the image distance of a small object on the axis of the rod, 8.00 cm to the left of the vertex.

(b) Find the lateral magnification.

Q6. (a) State with a diagram the Lensmaker's equation of a thin lens.

(b) The values of the radii of curvature of a lens surfaces are both equal to 10 cm and the index of refraction is n = 1.52. What is the focal length f of the lens?

Good Luck

Q1)

a)

1. **The incident, reflected, and refracted rays and the normal to the surface all lie in the same plane.** The plane of the three rays is perpendicular to the plane of the boundary surface between the two materials. We always draw ray diagrams so that the incident, reflected, and refracted rays are in the plane of the diagram.
2. **The angle of reflection θ_r is equal to the angle of incidence θ_a for all wavelengths and for any pair of materials.** That is, in Fig. 33.5c,

$$\theta_r = \theta_a \qquad \text{(law of reflection)} \tag{33.2}$$

   This relationship, together with the observation that the incident and reflected rays and the normal all lie in the same plane, is called the **law of reflection.**
3. For monochromatic light and for a given pair of materials, a and b, on opposite sides of the interface, **the ratio of the sines of the angles θ_a and θ_b, where both angles are measured from the normal to the surface, is equal to the inverse ratio of the two indexes of refraction:**

$$\frac{\sin\theta_a}{\sin\theta_b} = \frac{n_b}{n_a} \tag{33.3}$$

   or

$$n_a \sin\theta_a = n_b \sin\theta_b \qquad \text{(law of refraction)} \tag{33.4}$$

b)

$\theta_r = \theta_a = 60.0°$.

To find the direction of the refracted ray, we use Snell's law, Eq.(33.4), with $n_a = 1.33$, $n_b = 1.52$, and $\theta_a = 60.0°$. We find

$$n_a \sin\theta_a = n_b \sin\theta_b$$

$$\sin\theta_b = \frac{n_a}{n_b}\sin\theta_a = \frac{1.33}{1.52}\sin 60.0° = 0.758$$

$$\theta_b = 49.3°$$

Q2)

Wavelength:

$\lambda = \lambda_0/n$

$n = \lambda_0 / \lambda = 532/450 = 1.182$

Velocity:

$v = c/n$

$= 3\times10^8/1.182 = 2.54\times10^8$ m/s

Frequency:

$f = v/\lambda = 2.54\times10^8/450\times10^{-9} = 5.64\times10^{14}$ Hz

b) The ratio of the transmitted to incident amplitude is ($\cos\phi$), so the ratio of transmitted to incident intensity is ($\cos^2\phi$) . Thus the intensity of the light transmitted through the analyzer is

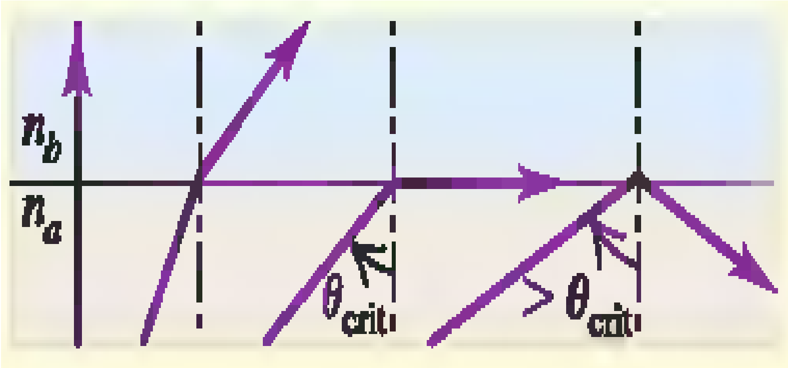
$$I = I_{max}\cos^2\phi \qquad \text{(Malus's law, polarized light passing through an analyzer)}$$

where I_{max} is the maximum intensity of light transmitted (at $\phi = 0$) and I is the amount transmitted at angle ϕ. This relationship, discovered experimentally by Etienne Louis Malus in 1809, is called Malus's law.

Q3)

Total internal reflection: When a ray travels in a material of greater index of refraction n_a toward a material of smaller index n_b, total internal reflection occurs at the interface when the angle of incidence exceeds a critical angle θ_{crit}

$$\sin\theta_{crit} = \frac{n_b}{n_a}$$

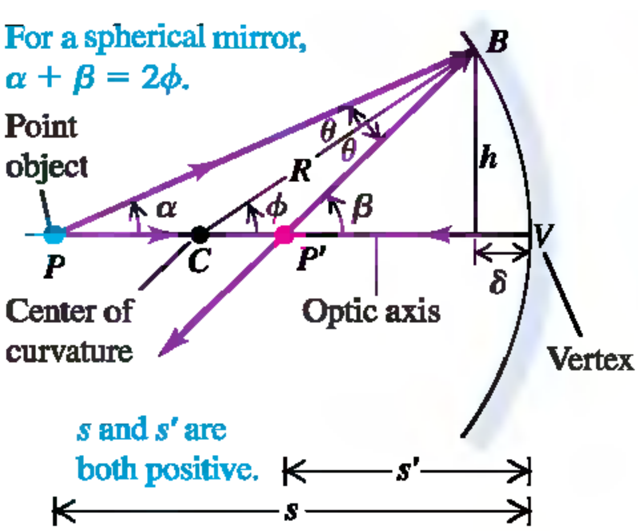


b)

this glass encounters a glass–air interface, the critical angle is

$$\sin\theta_{crit} = \frac{1}{1.52} = 0.658 \qquad \theta_{crit} = 41.1°$$

Q4)a)



We now use the following theorem from plane geometry: An exterior angle of a triangle equals the sum of the two opposite interior angles. Applying this theorem to triangles PBC and $P'BC$ in Fig. 34.10a, we have

$$\phi = \alpha + \theta \qquad \beta = \phi + \theta$$

Eliminating θ between these equations gives

$$\alpha + \beta = 2\phi \tag{34.3}$$

We may now compute the image distance s'. Let h represent the height of point B above the optic axis, and let δ represent the short distance from V to the foot of this vertical line. We now write expressions for the tangents of α, β, and ϕ, remembering that s, s', and R are all positive quantities:

$$\tan\alpha = \frac{h}{s - \delta} \qquad \tan\beta = \frac{h}{s' - \delta} \qquad \tan\phi = \frac{h}{R - \delta}$$

These trigonometric equations cannot be solved as simply as the corresponding algebraic equations for a plane mirror. However, *if the angle α is small,* the angles β and ϕ are also small. The tangent of an angle that is much less than one radian is nearly equal to the angle itself (measured in radians), so we can replace $\tan\alpha$ by α, and so on, in the equations above. Also, if α is small, we can neglect the distance δ compared with s', s, and R. So for small angles we have the following approximate relationships:

$$\alpha = \frac{h}{s} \qquad \beta = \frac{h}{s'} \qquad \phi = \frac{h}{R}$$

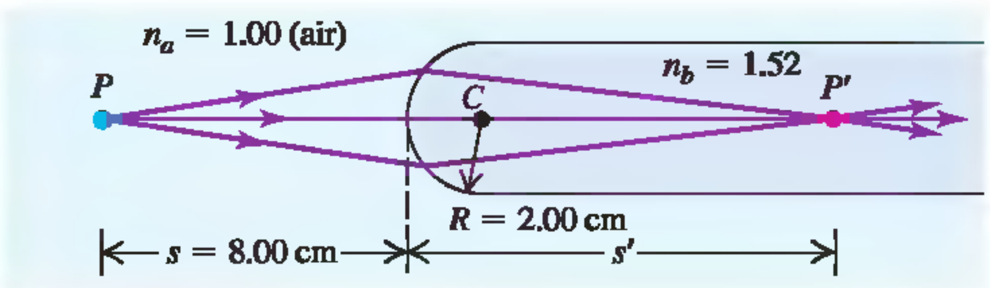
Substituting these into Eq. (34.3) and dividing by h, we obtain a general relationship among s, s', and R:

$$\frac{1}{s} + \frac{1}{s'} = \frac{2}{R} \quad \text{(object–image relationship, spherical mirror)} \tag{34.4}$$

b)

$$m = \frac{y'}{y} = -\frac{s'}{s} \quad \text{(lateral magnification, spherical mirror)}$$

Q5) a)



$$\frac{n_a}{s} + \frac{n_b}{s'} = \frac{n_b - n_a}{R} \qquad \text{(object–image relationship, spherical refracting surface)}$$

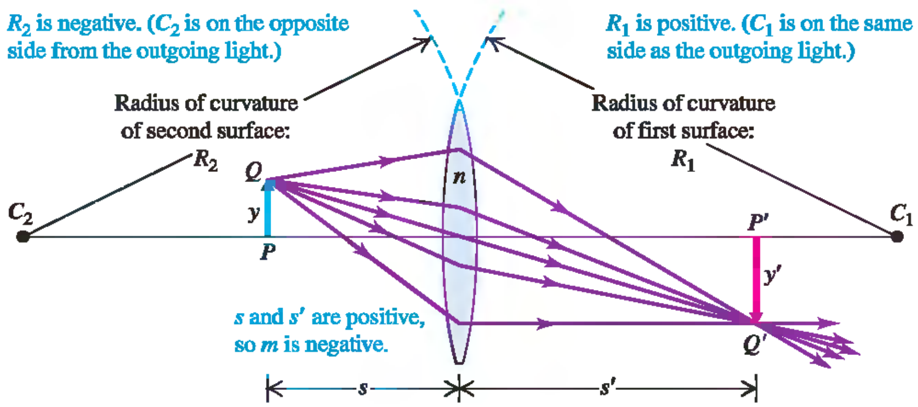
$$\frac{1.00}{8.00\text{ cm}} + \frac{1.52}{s'} = \frac{1.52 - 1.00}{+2.00\text{ cm}}$$

$$s' = +11.3\text{ cm}$$

b) To find lateral magnification:

$$m = -\frac{n_a s'}{n_b s} = -\frac{(1.00)(11.3\text{ cm})}{(1.52)(8.00\text{ cm})} = -0.929$$

Q6. a)



$$\frac{1}{s} + \frac{1}{s'} = (n - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (n - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \qquad \text{(lensmaker's equation for a thin lens)}$$

b) for a lens, R_1 is positive, but R_2 is negative

R_1=+10

R_2=-10

$$\frac{1}{f} = (1.52 - 1)\left(\frac{1}{+10\ \text{cm}} - \frac{1}{-10\ \text{cm}}\right)$$

$$f = 9.6\ \text{cm}$$