

## Reflection and Refraction

1. A ray of light strikes a mirror at an angle of  $53^\circ$  to the normal.
  - (a) What is the angle of reflection?
  - (b) What is the angle between the incident ray and the reflected ray?
2. A ray of light incident upon a mirror makes an angle of  $36.0^\circ$  with the mirror. What is the angle between the incident ray and the reflected ray?
3. A ray of light has an angle of incidence of  $30.0^\circ$  on a block of quartz and an angle of refraction of  $20.0^\circ$ . What is the index of refraction for the block of quartz?
4. A ray of light travels from air into a liquid. The ray is incident upon the liquid at an angle of  $30.0^\circ$ . The angle of refraction is  $22.0^\circ$ . What is the index of refraction of the liquid?
5. A ray of light, in air, is incident at an angle of  $60.0^\circ$  upon the surface of a piece of crown glass ( $n=1.52$ ). What is the angle of refraction?
6. A light ray strikes the surface of a pond ( $n_{\text{water}}=1.33$ ) at an angle of incidence of  $36.0^\circ$ . At what angle is the ray refracted?
7. Light is incident at an angle of  $60.0^\circ$  on the surface of a diamond ( $n=2.42$ ). Calculate the angle of refraction?
8. A ray of light has an angle of incidence of  $33.0^\circ$  on the surface of crown glass ( $n=1.52$ ). What is the angle of refraction into the air on the other side of the piece of glass?
9. A ray of light passes from water ( $n=1.33$ ) into crown glass ( $n=1.52$ ) at an angle of  $23.2^\circ$ . Calculate the angle of refraction.
10. Light goes from flint glass ( $n=1.61$ ) into ethanol ( $n=1.36$ ). The angle of refraction in the ethanol is  $25.0^\circ$ . What is the angle of incidence in the glass?
11. A beam of light strikes the flat, glass ( $n=1.50$ ) side of a water filled aquarium at an angle of  $40.0^\circ$  to the normal. At what angle does the beam
  - (a) enter the glass?
  - (b) enter the water?

### Numerical Answers

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|-------------------|-----------------|--------------------|
| 1. (a) $53^\circ$ | (b) $106^\circ$ | 10. $20.9^\circ$   |
| 2. $72^\circ$     |                 | 11. (a) $25^\circ$ |
| 3. 1.46           |                 | (b) $28.9^\circ$   |
| 4. 1.33           |                 |                    |
| 5. $34.7^\circ$   |                 |                    |
| 6. $26^\circ$     |                 |                    |
| 7. $21^\circ$     |                 |                    |
| 8. $33^\circ$     |                 |                    |
| 9. $20.2^\circ$   |                 |                    |