Section Twelve optics

Section one

Proposals have been made to "sail" spacecraft to the outer solar sys-tem using the pressure of sunlight, or even to propel interstellar space-craft with high-powered, Earth-based lasers. Sailing spacecraft would need no fuel—a great advantage because fuel constitutes much of the initial weight of any space mission. The first successful test of sunlight-powered sailing is the Japanese spacecraft IKAROS, launched in 2010

1. If a sunlight-powered sailing spacecraft accelerated at in the vicinity of Earth's orbit, what would be its acceleration at Mars, about 1.5 times as far from the Sun as Earth?

a. about 0.25 m/s^2

b. a little less than 0.25 m/s^2

c. a little more than 0.25 m/s^2

d. about 0.66 m/s^2

2. One spacecraft has a sail that absorbs all light incident on it; the other has a perfectly reflective sail. How do their accelerations compare in light with the same intensity?

a. The absorptive sail gives twice the acceleration.

b. The reflective sail gives twice the acceleration.

c. The absorptive sail gives greater acceleration, but not twice as much.

d. The reflective sail gives greater acceleration, but not twice as much.

3. A sail capable of propelling a spacecraft to the outer solar system must be able to overcome the Sun's gravity. Suppose a spacecraft is designed so the force of sunlight on its sail is 20 times that of solar gravity in the vicinity of Earth's orbit. If the spacecraft reaches Jupiter, some 5 times as far from the Sun as Earth,

a. the sail force will still exceed solar gravity, now by a factor of 4.

b. the sail force will be slightly less than solar gravity.

c. the sail force will now be 25 times solar gravity.

d. the sail force will still be 20 times solar gravity.

4. The intensity of sunlight at Earth's orbit is about 1.4 KW/A^2,A 100-kg sailing spacecraft with sail area would experience an acceleration of about

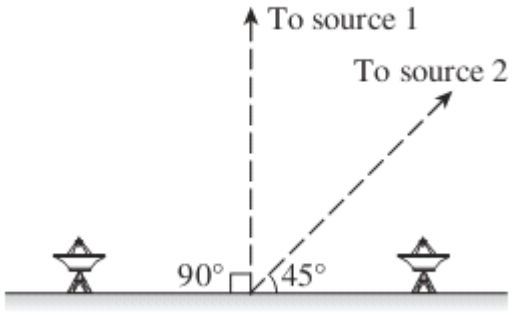
a. 5 mm/s^2

b. 5 cm/s^2

c. 5 m/s^2

d 5 km/s^2

Even the nearest stars are so distant that a single diffraction-limited telescope capable of imaging Earth-size planets orbiting them would be hopelessly large. Astronomers get around this limitation using interferometry to combine data from several telescopes, producing an instrument that acts like a single telescope with aperture equal to the distance between the individual telescopes. The technological challenge is to combine the signals with their relative phase intact; for this reason, interferometry has been used success-fully for decades in radio astronomy but is just beginning to be used with optical telescopes.



5. If the separation of two telescopes comprising an interferometer is doubled, the angular separation between two sources just barely re solvable by the interferometer will

a. not change.

b. decrease by a factor of

c. halve.

d. double.

6. If the separation of two telescopes comprising an interferometer is doubled, the instrument's light- collecting power will

a. not change.

b. increase by a factor of

c. double.

d. quadruple.

7. If a point source is located directly above a two-telescope interferometer, on the perpendicular bisector of the line joining the telescopes (source 1), electromagnetic waves reaching the two will be

a. in phase.

b. out of phase by 45 degrees

c. out of phase by 90 degrees

d. you can't tell without further information

8. If a point source is located on a line at 45 degrees to the line joining the two telescopes (source 2), electromagnetic waves reaching the two will be

a. in phase.

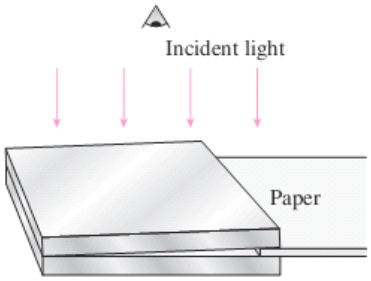
b. out of phase by 45 degrees

c. out of phase by 90 degrees

d. you can't tell without further information

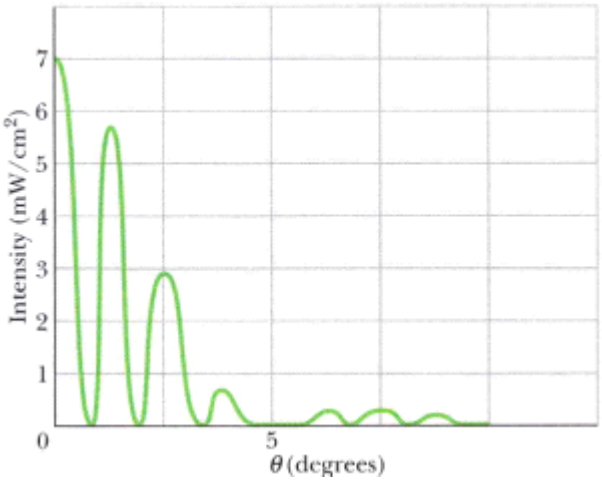
Section Two

1 Two perfectly flat glass plates are separated at one end by a sheet of paper 0.065 mm thick. 550-nm light illuminates the plates from above,. How many bright bands ap-pear to an observer looking down on the plates?

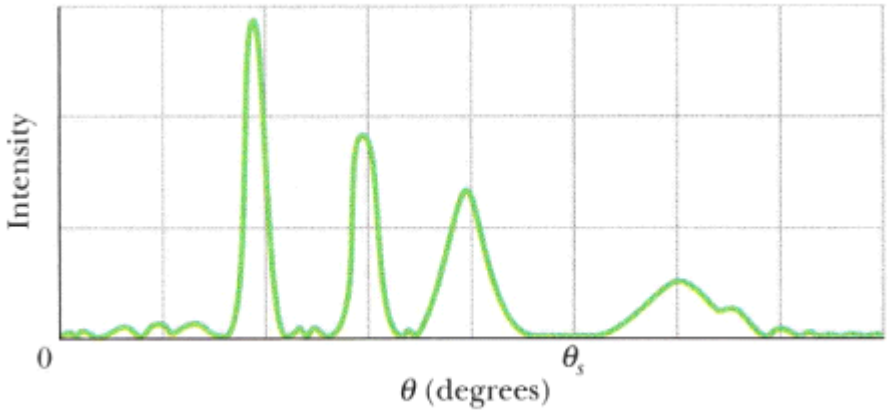


2 A beam of partially polarized light can be considered to be a mixture of polarized and unpolarized light. Suppose we send such a beam through a Polarizing filter and then rotate the filter through 360' while keeping it perpendicular to the beam. If the transmitted intensity varies by a factor of 5.0 during the rotation, what fraction of the intensity of the original beam is associated with the beam's polarized light?

3 Light of wavelength 440 nm passes through a double slit, yielding a diffraction pattern whose graph of intensity I versus angular position θ is shown in the figure . Calculate (a) the slit width and (b) the slit separation.



4 Figure below is a graph of intensity versus angular position θ for the diffraction of an x-ray beam by a crystal. The horizontal scale is set by θs=2.00°. The beam consists of two wavelengths, and the spacing between 0.94 nm. What are the (a) shorter and (b) longer wavelength in the beam.



5 A Michelson interferometer uses light from glowing hydrogen at 486.1 nm. As you move one mirror, 530 bright fringes pass a fixed point in the viewer. How far did the mirror move?