Physics 2020 Spring 2013: Discussion Problems for the Week of Apr 01

1. In astronomy, distances are often expressed in light-years. One light-year is the distance traveled by light in one year. The distance to Alpha Centauri, the closest star other than our own sun that can be seen by the naked eye, is 4.3 light-years. Express this distance in meters.

\[4.1 \times 10^{16} \text{ m}\]

2. Radio waves are used in the operation of a cellular telephone. To receive a call, the phone detects the wave emitted at one frequency by the transmitter station or base unit. To send your message to the base unit, your phone emits its own wave at a different frequency. The difference between these two frequencies is fixed for all channels of cell phone operation. Suppose that the wavelength of the wave emitted by the base unit is 0.34339 m and the wavelength of the wave emitted by the phone is 0.36205 m. Using a value of \(2.9979 \times 10^8\) m/s for the speed of light, determine the difference between the two frequencies used in the operation of a cell phone.

\[4.500 \times 10^7 \text{ Hz}\]

3. A future space station in orbit about the earth is being powered by an electromagnetic beam from the earth. The beam has a cross-sectional area of 135 m² and transmits an average power of \(1.20 \times 10^4\) W. What are the rms values of the (a) electric and (b) magnetic fields?

(a) 183 N/C  (b) \(6.10 \times 10^{-7}\) T

4. The drawing shows an edge-on view of the solar panels on a communications satellite. The dashed line specifies the normal to the panels. Sunlight strikes the panels at an angle \(\vartheta\) with respect to the normal. If the solar power impinging on the panels is 2600 W when \(\vartheta = 65^\circ\), what is it when \(\vartheta = 25^\circ\)?

5600 W
5. A distant galaxy is simultaneously rotating and receding from the earth. As the drawing shows, the galactic center is receding from the earth at a relative speed of \( u_G = 1.6 \times 10^6 \text{ m/s} \). Relative to the center, the tangential speed is \( v_T = 0.4 \times 10^6 \text{ m/s} \) for locations A and B, which are equidistant from the center. When the frequencies of the light coming from regions A and B are measured on earth, they are not the same and each is different from the emitted frequency of \( 6.200 \times 10^{14} \text{ Hz} \). Find the measured frequency for the light from

(a) region A  
(b) region B

6. In experiment 1, unpolarized light falls on the polarizer in Figure 24.21. The angle of the analyzer is \( \theta = 60.0^\circ \). In experiment 2, the unpolarized light is replaced by light of the same intensity, but the light is polarized along the direction of the polarizer's transmission axis. By how many additional degrees must the analyzer be rotated so that the light falling on the photocell will have the same intensity as it did in experiment 1? Explain whether \( \theta \) is increased or decreased by this additional number of degrees.

9.3°. The angle \( \theta \) is increased.

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**Figure 24.21** Two sheets of polarizing material, called the polarizer and the analyzer, may be used to adjust the polarization direction and intensity of the light reaching the photocell. This can be done by changing the angle \( \theta \) between the transmission axes of the polarizer and analyzer.
7. More than one analyzer can be used in a setup like the one in Figure 24.21, each analyzer following the previous one. Suppose that the transmission axis of the first analyzer is rotated 27° relative to the transmission axis of the polarizer, and that the transmission axis of each additional analyzer is rotated 27° relative to the transmission axis of the previous one. What is the minimum number of analyzers needed for the light reaching the photocell to have an intensity that is reduced by at least a factor of 100 relative to the intensity of the light striking the first analyzer?

8. You walk at an angle of \( \theta = 50.0^\circ \) toward a plane mirror, as in the drawing. Your walking velocity has a magnitude of 0.90 m/s. What is the velocity of your image relative to you (magnitude and direction)?

   1.2 m/s, in the -x direction

9. The radius of curvature of a convex mirror is 1.00 \( \times 10^2 \) cm. An object that is 10.0 cm high is placed 25.0 cm in front of this mirror. Using a ray diagram drawn to scale, measure (a) the location and (b) the height of the image. The mirror must be drawn to scale.

   (a) The image is located 16.7 cm behind the mirror.  
   (b) 6.67 cm

10. A concave mirror (\( R = 56.0 \) cm) is used to project a transparent slide onto a wall. The slide is located at a distance of 31.0 cm from the mirror, and a small flashlight shines light through the slide and onto the mirror. The setup is similar to that in Figure 25.18a.

   (a) How far from the wall should the mirror be located?
   (b) The height of the object on the slide is 0.95 cm. What is the height of the image?
   (c) How should the slide be oriented, so that the picture on the wall looks normal?

   (a) 290 cm  
   (b) -8.9 cm  
   (c) upside down
11. When viewed in a spherical mirror, the image of a setting sun is a virtual image. The image lies 12.0 cm behind the mirror.

(a) Is the mirror concave or convex? Why?
(b) What is the radius of curvature of the mirror?
   (a) convex  (b) 24.0 cm

12. An object is placed in front of a convex mirror, and the size of the image is one-fourth that of the object. What is the ratio $d_o/f$ of the object distance to the focal length of the mirror?
   -3