Part O Problems

1. The Sun is about 93 million miles away. When light from the Sun eventually is turned off, how long after the sun burns out will Earth observers notice it?

2. What frequency of oscillation of electric charges will create light waves with a wavelength comparable to the diameter of a nucleus, 1.0×10^{-15} m?

3. A mixture of beams of light consists of 30 W/m^2 of yellow light and 15 W/m^2 of blue light. What is the resulting color of the mixture?

4. What color of light, and in what intensity, must be mixed with 20 W/m^2 of magenta light and 20 W/m^2 of cyan light to create a mixture that is white?

5. A mixture of three beams of light consists of 60 W/m^2 of yellow, 30 W/m^2 of blue, and 5 W/m^2 of green. What is the resulting color?

6. After magenta light passes through a cyan filter, the transmitted light is incident on a green apple. What color is the apple to the eye of an observer?

7. White light passes through a magenta filter, then that transmitted light passes through a cyan filter, and, finally, that transmitted light passes through a yellow filter and lands on a cyan grape. What color is the grape to the eye of an observer?

8. A light source emitting green light of frequency 6.0×10^{14} Hz is traveling toward Earth at 0.30 times the speed of light. (a) What is the emitted wavelength in nanometers (nm)? (b) What frequency is observed on earth? (c) What wavelength (in nm) is observed? (d) Is the light blue-shifted, or red-shifted?

9. A certain component of light from a distant galaxy has a frequency of 5.0×10^{14} Hz. On Earth, the observed frequency is 4.6×10^{14} Hz. (a) What is the speed of the galaxy relative to Earth? (b) Was this light red-shifted, or blue-shifted?

10. Ten meters away from a spherically-symmetric light source the intensity is 4.0 W/m^2. What is the intensity 3.0 meters from the source?

Solutions

1. The sun is 93 million miles from Earth. The speed of light is 186,000 miles/second:

$93 \times 10^6 / 186000 = 500$ s

2. $f = 3 \times 10^8 / 1 \times 10^{-15}$
$= 3 \times 10^{23}$ Hz

3.
30 Y = 15 R+15 G
Add 15 B:
(15 R + 15 G) + 15 B = 45 W

45 watts/m^2 of white light is created

4.

20 M + 20 C = (10 R + 10 B) +(10 G + 10 B)
= 10 R + 10 G + 20 B
Add 10 R and 10 G (i.e., 20 watts/m^2 of yellow)
20 R + 20 G + 20 B = 60 watts/m^2 of white light

5. 60 Y + 30 B + 5 G = (30 R + 30 G) + 30 B + 5 G
= (30 R + 30 G + 30 B) + 5 G
= 90 W + 5 G
= 95 watts/m^2 of pale green light

6. M = R + B is incident on a filter that only lets G and B through.

B gets through and lands on an object that absorbs R an B and reflects the remainder.

The only light landing on the apple is B, but the apple absorbs B.
No light is reflected: the apple is K (black).

7. RB passes through the M filter, but only B gets through the C filter. The B is blocked by the yellow filter, so the grape receives no light, and therefore is K.

8. (a)
$\lambda = 3.0 \times 10^8 / 6 \times 10^{14} = 5 \times 10^{-7}$ m
$= 500 \times 10^{-9}$ m
= 500 nm
(b) $f_o = 6.0 \times 10^{14} (1+0.3)$
$= 7.8 \times 10^{14}$ Hz
(c) $\lambda_o = 3.0 \times 10^8 / 7.8 \times 10^{14}$
$= 3.85 \times 10^{-7}$ m
= 385 nm
(d) shortened from 500 nm to 385 nm
"blue-shifted"

9. Before the correction below was made, I had stated the "Observed frequency is higher, so the galaxy is moving toward Earth." The correct wording is below.

Observed frequency is LOWER, so the galaxy is moving AWAY FROM Earth. Use the negative sign:

(a) $4.6 = 5.0\ (1 - v/c)$
$v/c = 0.08$
$v = 2.4 \times 10^7$ m/s

(b) f_o is lower, therefore λ is longer:
light is red-shifted.

10.
First, solve for the unknown output power, P:

$r_1 = 10$ m
$I_1 = 4.0$ W/m^2

$I_1 = P / (4\pi r_1^2)$
$4.0 = P / (4\pi\ 10^2)$
$P = 5027$ W

Now calculate the intensity at $r_2 = 3.0$ m:

$I_2 = P / (4\pi r_2^2)$
$= 5027 / (4\pi\ 3.0^2)$
$= 44.4$ W/m^2