Physics 30 – Lesson 24
Electromagnetic Waves

/ 69

1)

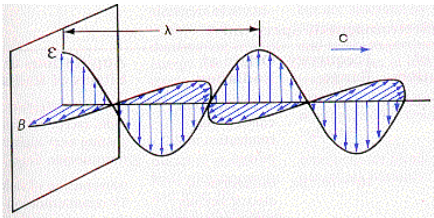
/4

A) The source of all electromagnetic radiation is **accelerating charges**.

B) $f_{oscillation} = f_{EMR}$

C) $c = 3.00 \times 10^8 \, \frac{m}{s}$

D)



2) /2 All of them have electric fields and magnetic field vibrating perpendicular to each other that radiate through space. Hence – electromagnetic radiation.

3)

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A) AC power, radio, radar, TV, microwaves

B) Infrared, visible light, UV light

C) X-rays

D) Gamma rays

4) /2 Radio waves and visible light waves are similar in that both are electromagnetic radiation with the same speed. They have different frequencies and wavelengths.

5) /2 x-rays and visible light waves are similar in that both are electromagnetic radiation with the same speed. They have different frequencies and wavelengths.

6) /3 As the frequency of waves increases the wavelength *decreases*. The range of wavelengths for visible light from *375nm* to *750nm*. Which type of wave would penetrate the human body more easily, X-rays or $\boxed{\text{gamma rays}}$

7) /3 The polar water molecules in food have a natural frequency of vibration in the microwave range of the electromagnetic spectrum. The oscillating electric field of microwaves cause the water molecules to vibrate. Increased vibration = increased heat. Another application for microwaves is telecommunications across the country.

8) /1 Due to the heat of our bodies we continually radiate infrared radiation which can be detected in the "dark".

9) /1 Honey bees see light in the ultra violet part of the spectrum that human eyes are incapable of seeing.

10) /2 X-rays penetrate soft tissue and are stopped by bones and hard tissue. An x ray photo is the x-ray shadow of a bone.

11) /1 North – south.

12)

$a)\ f=\dfrac{c}{\lambda}$ $\qquad b)\ \lambda=\dfrac{c}{f}$ $\qquad c)\ \lambda=\dfrac{c}{f}$ $\qquad d)\ f=\dfrac{c}{\lambda}$

/8

$f=\dfrac{3.0\times10^{8}\ m/s}{0.018m}$ $\qquad \lambda=\dfrac{3.0\times10^{8}\ m/s}{3.2\times10^{10}\,Hz}$ $\qquad \lambda=\dfrac{3.0\times10^{8}\ m/s}{60Hz}$ $\qquad f=\dfrac{3.0\times10^{8}\ m/s}{650\times10^{-9}\,m}$

$\boxed{f=1.7\times10^{10}\,Hz}$ $\qquad \boxed{\lambda=9.4\times10^{-3}\,m}$ $\qquad \boxed{\lambda=5.0\times10^{6}\,m}$ $\qquad \boxed{f=4.6\times10^{14}\,Hz}$

13)

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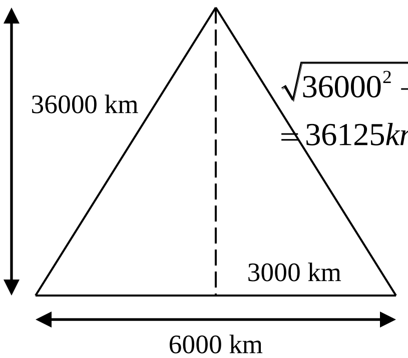

$\sqrt{36000^2+3000^2}$
$=36125km$

$d=2\times36125km$ (up + down)

$\Delta t=\dfrac{d}{v}$

$\Delta t=\dfrac{2\times36125\times10^{3}m}{3.0\times10^{8}\ m/s}$

$\boxed{\Delta t=0.24s}$

14)

$c=\lambda f \qquad f=\dfrac{1}{T}$

/3

$c=\dfrac{\lambda}{T}$

$\lambda=cT$

$\lambda=3.0\times10^{8}\ m/s\,(5.65\times10^{-11}\,s)$

$\boxed{\lambda=0.0170m}$

15)

$\dfrac{\lambda_1}{\lambda_2}=\dfrac{n_2}{n_1}$

/3

$\lambda_2=\dfrac{\lambda_1 n_1}{n_2}$

$\lambda_2=\dfrac{(11.0\,nm)(1.00)}{1.52}$

$\boxed{\lambda_2=7.24\,nm}$

16) The period and frequency do not change when speed and wavelength change.

/3

$\therefore T=\dfrac{\lambda_1}{c}$

$T=\dfrac{7.30\times10^{-8}m}{3.0\times10^{8}\ m/s}$

$\boxed{T=2.43\times10^{-16}s}$

17)

$$\Delta t = \frac{d}{v}$$

/3

$$\Delta t = \frac{2 \times 7.60 \times 10^{12}\, m}{3.0 \times 10^{8}\ {}^{m}\!/_{s}}$$

$$\boxed{\Delta t = 5.07 \times 10^{4}\, s}$$

18) since x>>L we have to calculate θ first and then use the double-slit formula

/6

$$\tan\theta = \frac{x}{L}$$

$$\theta = \tan^{-1}\left(\frac{x}{L}\right)$$

$$\theta = \tan^{-1}\left(\frac{14.5}{1.5}\right)$$

$$\theta = 84.09386^{\circ}$$

$$\lambda = \frac{d\sin\theta}{n}$$

$$\lambda = \frac{0.0500m(\sin 84.09386)}{1}$$

$$\lambda = 0.049735m$$

$$f = \frac{c}{\lambda}$$

$$f = \frac{3.0 \times 10^{8}\ {}^{m}\!/_{s}}{0.049735m}$$

$$\boxed{f = 6.03 \times 10^{9}\, Hz}$$

19)

$$\sin\theta = \frac{n\lambda}{d}$$

$$\sin\theta = \frac{n\left(\frac{c}{f}\right)}{d}$$

/6

$$\theta_{\max} = \sin^{-1}\frac{nc}{df}$$

$$\theta_{\max} = \sin^{-1}\left(\frac{(1)(3.0 \times 10^{8}\ {}^{m}\!/_{s})}{(0.0300m)(8.00 \times 10^{10}\, Hz)}\right)$$

$$\boxed{\theta_{\max} = 7.2^{\circ}}$$

$$\theta_{\min} = \sin^{-1}\left(\frac{(n - \frac{1}{2})c}{df}\right)$$

$$\theta_{\min} = \sin^{-1}\left(\frac{(1 - \frac{1}{2})(3.0 \times 10^{8}\ {}^{m}\!/_{s})}{(0.0300m)(8.00 \times 10^{10}\, Hz)}\right)$$

$$\boxed{\theta_{\min} = 3.6^{\circ}}$$

20)

$$f_1 = \frac{c}{\lambda_1}$$

$$f_1 = \frac{3.0 \times 10^{8}\ {}^{m}\!/_{s}}{0.0135m}$$

/6

$$\boxed{f_1 = 2.22 \times 10^{10}\, Hz}$$

$$f_2 = \frac{3.0 \times 10^{8}\ {}^{m}\!/_{s}}{0.18m}$$

$$\boxed{f_2 = 1.7 \times 10^{9}\, Hz}$$

these are microwaves

21)

a) The source of all electromagnetic radiation is an accelerating <u>charged</u> particle.
b) Electromagnetic radiation having a frequency of 1.0 x 10^{15} Hz would be classified as <u>ultra violet</u> radiation.
c) When an electromagnetic wave passes from one material into another with a higher index of refraction, its frequency will <u>not change</u>.

/3