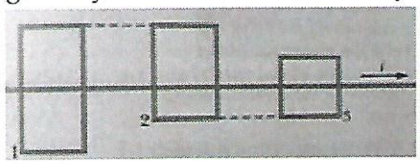
Exam 3

Name KEY

27 Questions

Select the one response that best answers each question.

1) The figure shows a long straight wire carrying a current 'i'. That wire passes across three rectangular loops, but is insolated so that there is no electrical connection between the wire and the loops. All of the loops have the same width, but they have different heights. Loops 1 and 3 are symmatric about the long wire. Loop 2 is not. The loops are far enough away from each other that they do not interact.



How do the magnitudes of the induced currents compare if the current 'i' is constant?

A) 1 = 2 = 3 B) 1 > 2 > 3 C) 1 = 3 > 2 D) 2 > 1 = 3

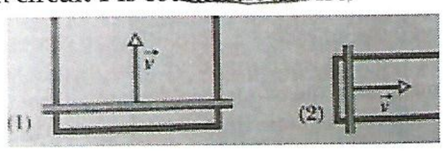
2) For the figure described in question 1, how do the magnitudes of the induced currents compare if the current 'i' is increasing?

A) 1 = 2 = 3 B) 1 > 2 > 3 C) 1 = 3 > 2 D) 2 > 1 = 3

3) For the figure described in question 1, how do the magnitudes of the induced currents compare if the current 'i' is decreasing?

A) 1 = 2 = 3 B) 1 > 2 > 3 C) 1 = 3 > 2 D) 2 > 1 = 3

4) The figure shows two circuits in which a conducting bar is slid at the same speed, v, along a U-shaped wire through the same uniform magnetic field. The parallel lengths of the wire are seperated by a distance of 2L in circuit 1 and a distance of L in circuit 2. There is an electrical connection between the bar and the U-shaped wire. The current induced in circuit 1 is counterclockwise.



What is the direction of the magnetic field?
HINT: Begin by thinking about how the flux must be changing through circuit 1.

A) in B) out C) left D) down

5) For the figure described in question 4, what is the direction of the induced current in circuit 2?

A) clockwise
B) counterclockwise
C) there is no induced current
D) more information is needed

6) For the figure described in question 4, how do the magnitudes of the induced currents compare?

A) 1 = 2
B) 1 < 2
C) 1 > 2
D) there is no way to tell

$\Phi_1 = BA_1 = B(2L)(x)$ $\uparrow vt$ $|\Delta V_1| = 2BLv$

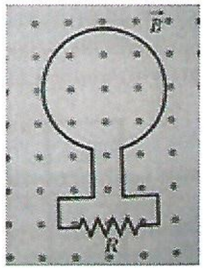
$\Phi_2 = BA_2 = B(L)(x) \leftarrow$ $|\Delta V_2| = BLv$

Perfect wires (no R mentioned)

7) In the figure shown, the magnetic flux through the loop increases with time in the following way: $\Phi_B = 6t^2 + 7t$,where the units are SI. Note that the magnetic flux is coming out of the page.

$|\Delta V| = 12t + 7$ ↑ Increasing

$@ t=2 \Rightarrow 31V$



What is the magnitude of the induced voltage at the instant when t = 2 seconds?

A) 38 volts B) 0 volts C) 7 volts D) 31 volts

8) For the figure described in question 7, what is the direction of the induced current through the resistor when t = 2 seconds?

A) from left to right
B) from right to left
C) there is no current
D) more information is needed

9) For the figure described in question 7, what is the direction of the induced current through the resistor when t = 0?

$\frac{d\Phi}{dt} = 12t + 7$

@ t=0 is INCREASING

A) from left to right
B) from right to left
C) there is no current
D) more information is needed

10) In the figure shown, the square loop of wire has sides of length 2 m. A non–uniform, time varying magnetic field is directed out of the page. Its magnitude is given by $B(y,t) = 4t^2y$, in SI units.

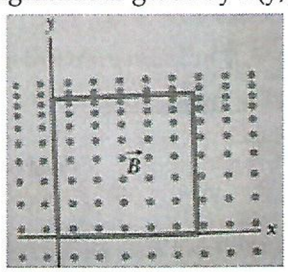
$\Phi = \int B \cdot dA = \int_0^2\int_0^2 4t^2 y \, dx\,dy$

$= 8t^2 \left(\frac{y^2}{2}\right)\Big|_0^2 = 16t^2$

↑ always increasing

$|\Delta V| = \left|-\frac{d\Phi}{dt}\right| = 32t$

$|\Delta V|\Big|_{t=2.5} = 80V$



At t=2.5 seconds, what is the magnitude of the voltage induced in the loop?

A) 80 volts B) 100 volts C) 50 volts D) 250 volts

11) For the figure described in question 10, at t = 2.5 seconds what is the direction of the induced current?

A) counterclockwise
B) clockwise
C) there is no current
D) more information is needed

Φ is increasing out.

12) Assume that a television station is broadcasting its 1 MW signal isotropically, as a point source (which is not really what happens). What is the intensity of that signal when it reaches Proxima Centauri? Proxima Centauri is the star nearest our solar system. It is 4.3 light years (4.07×10^{16} meters) away from us. Note that the surface area of a sphere is $4\pi r^2$.

A) 2.0×10^{-24} W/m^2 B) 6.0×10^{-28} W/m^2 C) 4.8×10^{-29} W/m^2 D) 2.5×10^{-11} W/m^2

$I = \frac{1 \times 10^6}{4\pi (4.07 \times 10^{16})^2} =$

$-\hat{i}$

13) Consider the electromagnetic wave whose electric field is given by the equation $\mathbf{E} = 2\cos[(1*10^7)x + (3*10^{15})t]\,\hat{\mathbf{k}}$. All units are SI. What is the amplitude of its magnetic field?

$B = \frac{E}{c} = \frac{2}{3\times10^8}$

A) 2

B) 6.7×10^{-9} ✓

C) more information is needed

D) 6.0×10^8

14) For the wave in question 13, along which axis does the magnetic field oscillate?

$\vec{S}$ $\vec{J}$ $\vec{B}$ $\vec{E}$ $\hat{i}$

A) z–axis

B) x–axis

C) y–axis ✓

D) more information is needed

15) For the wave in question 13, when the electric field at a given location is in the $+\hat{k}$ direction, in what direction is the magnetic field at that location?

A) $-\hat{i}$

B) $+\hat{i}$

C) $-\hat{j}$

D) $+\hat{j}$ ✓

16) An airplane flying at a distance of 10 km from a radio transmitter receives a signal whose intensity is 10 μW/m^2. What is the amplitude of the electric field that the airplane is receiving? $I = 10 \times 10^{-6} = E_{max}^2/2\mu_0 c$

A) 8.68×10^{-2} V/m ✓

B) 10×10^{-6} V/m

C) 7.96×10^{-15} V/m

D) 5.0×10^{-6} V/m

17) For the airplane of question 16, what is the amplitude of the magnetic field the plane is receiving?

$B = \frac{E}{c}$

A) 5.0×10^{-6} T

B) 3.15×10^{3} T

C) 2.5×10^{-11} T

D) 2.9×10^{-10} T ✓

18) For the airplane of question 16, what is the transmission power of the radio transmitter? Assume that the transmitter is transmitting uniformaly over a hemisphere. The surface are of a sphere is $4\pi r^2$.

$I = \frac{P}{A}$

A) 3.14 kW

B) 12.56 kW

C) 6.28 kW ✓

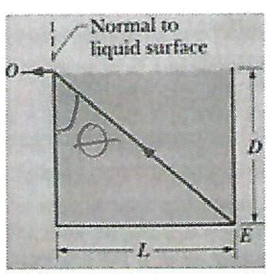
D) 1.57 kW

$\therefore P = IA = 10 \times 10^{-6} \times (2\pi(10\times10^3)^2) =$

19) The rectangular, metal tank shown in the figure is filled with an unknown liquid. The observer 'O', whose eyes are level with the top of the tank, can just see the corner 'E'. The light ray that refracts toward 'O' at the top surface of the liquid is shown.

$n\sin(52.3) = 1\sin(90)$

$n = 1.26$



$\theta = \tan^{-1}\left(\frac{1.1}{.85}\right) = 52.3^\circ$

If D=85 cm and L=1.1 m, what is the index of refraction for the liquid? The index of refraction for air is 1.

A) 1.26 ✓

B) 0.79

C) 1.64

D) 1.33

20) A concave shaving mirror has a focal length of 17.5 cm. It is positioned so that the upright image of a man's face is 2.5 times as large as his actual face. How far is the mirror from the man's face? HINTS: The second sentence is giving you the magnification . Your unknowns are the image distance and object distance. Make a substitution to get an equation whose only unknown is the object distance.

A) 24.5 cm B) 17.5 cm C) 10.5 cm ✓ D) 7 cm

21) A movie camera has a single converging lens whose focal length is 75 mm. It takes a picture of a person standing 27 meters away. If the person is 1.8 meters tall, what is the height of the image on the film?

A) +5.0 mm B) -5.0 mm ✓ C) -2.78mm D) +2.78mm

22) A puddle of water (n=1.33) has a thin film of gasoline (n=1.40) floating on it. A beam of light whose wavelength is 480 nm is shining onto the film from the air (n=1) above. What is the minimum thickness of the film if we see a bright reflection? $\Delta L = 2t = \frac{\lambda_f}{2}$ $\therefore t = \frac{\lambda_f}{4} = 85.7$ no answer listed

1.4

$\lambda_f = \frac{480}{1.4}$ 1.33

A) 360 nm B) 343 nm ~~C) 171 nm~~ D) 240 nm E) 480 nm

$\frac{3\lambda_f}{4} \Rightarrow 257$ $5\lambda_f/4 \Rightarrow 470$

23) Anti-reflective coatings are applied to surfaces to reduce the amount of light that is reflectied from the surface. An anti-reflective coating is to be applied to a pane of glass. The coating is being applied to reduce the reflection of light whose frequency is 5.75×10^{14} Hz. If the coating material has an index of refraction of 1.375 and the glass has an index of refraction of 1.537, what is the minimum thickness the coating should have? Note that the incident light begins in air and strikes the coating before it strikes the glass.

A) 65.2 nm B) 60.0 nm C) 145 nm D) 94.9 nm ✓ E) 80.1 nm

24) Light whose wavelength is 5.0×10^{-7} meters illuminates a soap film ($n = 1.33$) having air on both sides of it. When viewing the light reflected from the film, what is the minimum thickness of the film that will give an interference maximum?

A) 188 nm B) 94.0 nm ✓ C) 279 nm D) 24.0 nm E) 376 nm

25) When light travels from one material into another material that has a HIGHER index of refraction, __________.

$n_1 = \frac{c}{v_1}$ | $n_2 = \frac{c}{v_2}$

$\lambda_1 f = v_1$ | $\lambda_2 f = v_2$

$n_1 < n_2$

A) its speed decreases but its wavelength and frequency both increase.
B) its speed decreases but its frequency and wavelength stay the same.
C) its speed, wavelength, and frequency all decrease.
D) its speed increases, its wavelength decreases, and its frequency stays the same.
E) its speed and wavelength decrease, but its frequency stays the same. ✓

24.)

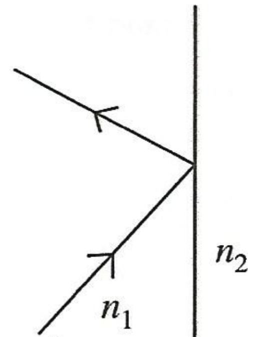
$\Delta L = \frac{\lambda_f}{2}$

$t = \frac{\lambda_f}{4}$

$t = 94 \times 10^{-9}$

$\lambda_f = \frac{5 \times 10^{-7}}{1.33}$

26) A ray of light strikes a boundary between two transparent materials, and there is no transmitted ray, as shown in the figure. What can you conclude about the indices of refraction of these two materials?



A) $n_2 \geq n_1$ B) $n_2 > n_1$ C) $n_1 > n_2$ D) $n_1 \geq n_2$ E) $n_1 = n_2$

27) A convex lens has focal length f. If an object is located extremely far from the lens (at infinity), the image formed is located what distance from the lens?

A) f
B) between f and $2f$
C) infinity
D) $2f$
E) between the lens and f

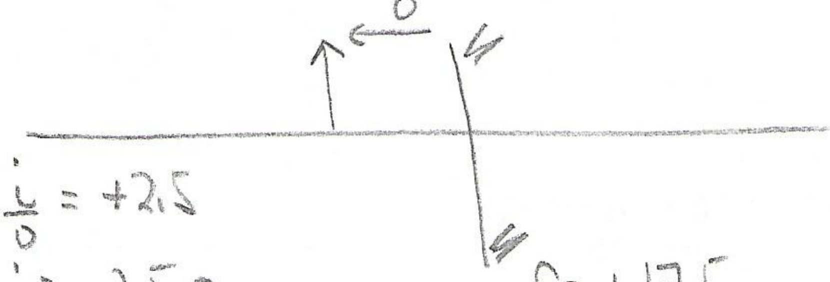
$\frac{1}{i} + \frac{1}{o} = \frac{1}{f}$

$o \to \infty$

$\frac{1}{i} = \frac{1}{f}$

$i = f$

20)



$M = -\frac{i}{o} = +2.5$

$\therefore i = -2.5o$

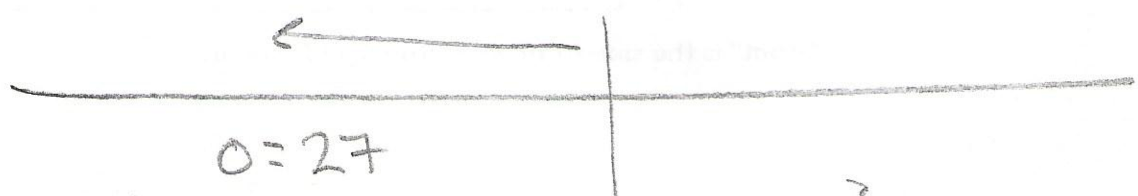
$f = +17.5$

$$\frac{1}{i} + \frac{1}{o} = \frac{1}{17.5}$$

$$-\frac{1}{2.5o} + \frac{1}{o} = \frac{1}{17.5}$$

$$\underline{10.5} = 17.5\left(-\frac{1}{2.5} + 1\right) = o$$

21)



$o = 27$

$h_o = 1.8$

$f = 75 \times 10^{-3}$

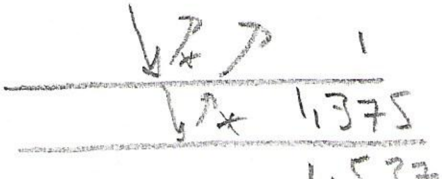
$$\frac{1}{i} + \frac{1}{27} = \frac{1}{75 \times 10^{-3}}$$

$\therefore i = 75.21 \times 10^{-3}$

$M = -\frac{i}{o} = -2.79 \times 10^{-3} = \frac{h_i}{h_o}$

$\therefore h_i = -\underline{5 \times 10^{-3}}$

23)



$\Delta L = 2t = \frac{\lambda_f}{2}$

$\therefore t = \underline{94.9} \times 10^{-9}$

$\lambda = \frac{3 \times 10^8}{5.75 \times 10^{14}} = 5.22 \times 10^{-7}$

$\lambda_f = \frac{5.22 \times 10^{-7}}{1.375} = 3.79 \times 10^{-7}$