PHYS 202 Equations Sheet You may tear this page T3 S23 Key

1. Force on a moving electric charge in a magnetic field: $F = qVBsin\theta$.

2. Force on a moving electric charge in an electric field. $F = q \times E$

3. Centripetal force: $F_c = m\frac{v^2}{r}$

4. Force on a current in a magnetic field. $F = I \times L \times B \times Sin\theta$

5. Magnetic field produced by electric current: $B = \frac{\mu_0 I}{2\pi r}$

6. Faraday's law of induction and Magnetic flux: $\xi = -N\frac{\Delta\Phi}{\Delta t}; \Phi = B_{\perp}A.$

7. Equations for transformers and power loss during transmission are shown below:

$\frac{V_s}{V_P} = \frac{N_s}{N_P}$ $I_S V_S = I_P V_P$ P = IV $P_{loss} = I^2 R$ V = IR $V_{rms} = \frac{V_P}{\sqrt{2}}$

8. Reactance (X_C) of a capacitor and Reactance (X_L) of an inductor:

$\chi_C = \frac{1}{2\pi fC}$. $\chi_L = 2\pi fL.$ $f = \frac{1}{T}$

9. Impedance (Z) of a series RCL circuit:

$$Z = \sqrt{(R^2 + (\chi_L - \chi_C)^2}.$$

10. Resonant frequency (f_0) of a series RCL circuit: $f_0 = \frac{1}{2\pi\sqrt{LC}}$.

11. Electromagnetic waves: $c = \frac{E}{B}$ $c = \lambda f$

12. Circumference, C and Area, A of a circle (radius r): $C = 2\pi r$ $A = \pi r^2$
Area of a rectangle = length x width. Area of a triangle $= \frac{1}{2} \times base \times height$

13. Proton charge = 1.6×10^{-19}C. Proton mass = 1.673×10^{-27} kg

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A. Select the correct answer for the multiple choices questions and write your answer in the line next to the question number. Write down your answers for other questions/problems.

C 1. The angle that the magnetic field of the earth makes with respect to the surface at any point is:

a. angle of declination
b. angle of rotation
c. angle of dip
d. angle of latitude

2-3) The magnetic force, F on a moving charge in a magnetic field is given by:

$$F = qVBsin\theta$$

2. Define θ, in the above equation: Angle between V and B. (V ↑ velocity, B ↑ magnetic field)

b 3. The SI unit for magnetic field, T is equivalent to:

a. $\frac{N.m}{C.s}$ b. $\frac{N.s}{C.m}$ c. $\frac{N}{C.s}$ d. $\frac{N.s}{C}$ e. $\frac{N.m}{C}$

d 4. At a location near the equator, the earth's magnetic field is horizontal and points north. An electron is moving vertically downward to the ground. What is the direction of the magnetic force that acts on the electron?

a. North b. South c. East d. West

b 5. Which one of the following is a unit for electromagnetic power?

a. C b. W c. J d. T e. Wb f. A

d 6. Who is credited for generating and detecting electromagnetic waves for the first time?

a. Maxwell b. Henry c. Tesla d. Hertz e. Faraday

C 7. What is the angle between the E and B fields in an electromagnetic wave?

a. 0^0 b. 45^0 c. 90^0 d. 120^0 e. 180^0

b 8. Which one of the following is not a ferromagnetic material?

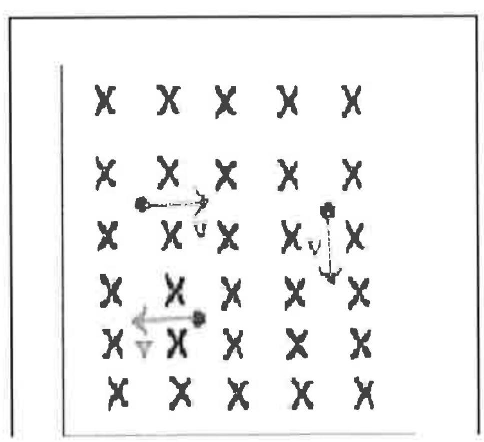
a. iron b. aluminum c. cobalt d. alnico e. chromium

D 9. Which one of the electromagnetic waves is used for medical imaging of the human body?

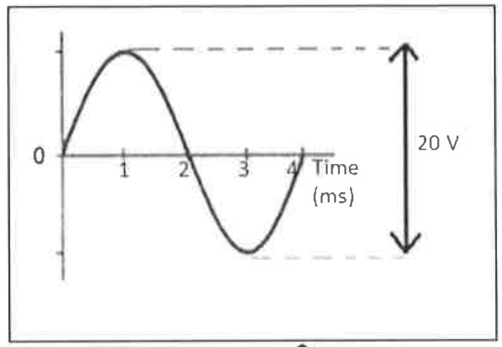
A. radio wave B. ultraviolet C. Gamma D. X-ray E. Infrared

b 10. Refer the figure to the right. The magnetic field is into the page. What is the direction of the magnetic force on the bottom charge, which is proton and moving to the left?

a. UP b. DOWN c. LEFT
d. RIGHT e. OUT f. IN



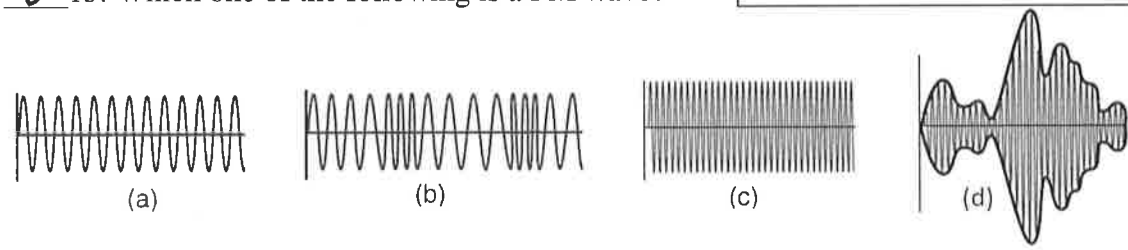
11-12) Consider the ac voltage shown to the right:



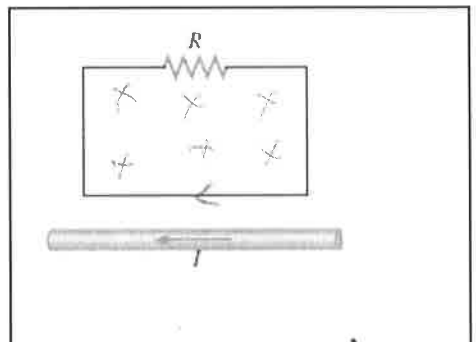
_a_ 11. What is the rms voltage for the ac voltage?
a. 7.1 V b. 10 V b. 14 V d. 20 V

_a_ 12. What is the frequency of the ac voltage?
a. 250 Hz b. 500 Hz c. 750 Hz e. 1000 Hz

_b_ 13. Which one of the following is a FM wave?



14-16) The drawing shows a straight wire carrying a current I. Above the wire is a rectangular loop that contains a resistor R, located in the same plane as straight wire.



_b_ 14. What is the direction of the magnetic field inside the loop?
a. coming out (·) b. going in (X)

_c_ 15. If the current I is constant, what is the direction of the induced current through the loop?

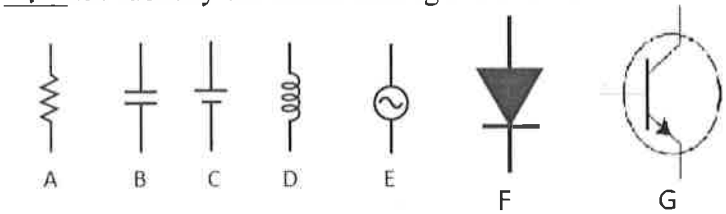
_a_ 16. If the current I is decreasing in time, what is the direction of the induced current through the loop? → X ↓, induced current needs to produce X

Answers for 15 & 16
a. clockwise b. counterclockwise c. no current

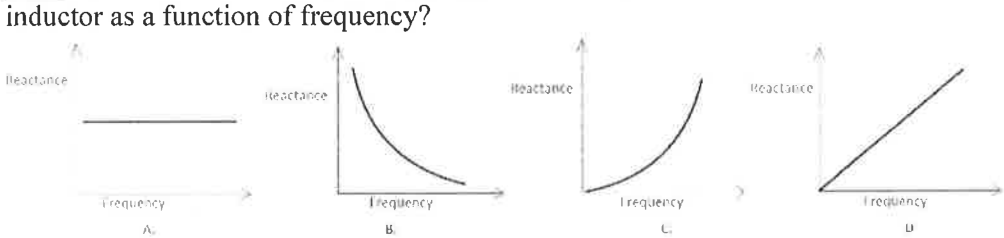
_d_ 17. Radio waves travel at the speed of light, 3.0×10^8 m/s. What is the wavelength of the 1000 kHz radio wave? (k = 10^3) $3 \times 10^8 = 1000 \times 10^3 \times \lambda$
a. 0.3 m b. 3 m c. 30 m d. 300 m e. 3.0×10^5 m

_B_ 18. Identify the capacitor among the circuit elements shown below:

_F_ 19. Identify the diode among the circuit elements shown below:

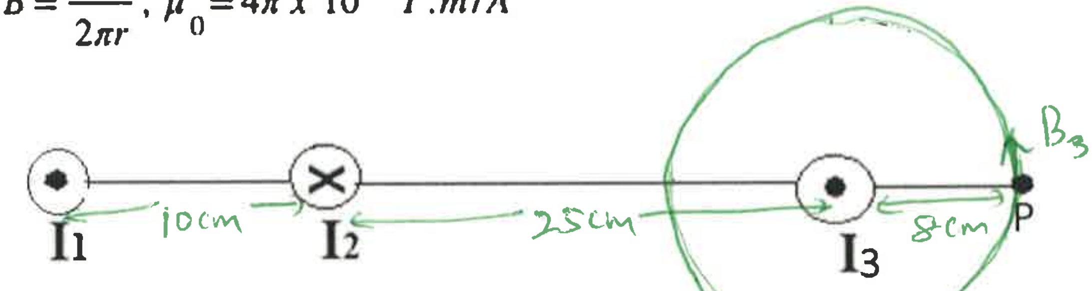


_D_ 20. Which one of the following figures correctly shows the variation of reactance of an inductor as a function of frequency?



B. The magnetic field (B) due to a long straight wire, carrying a current (I), at a distance (r) is given by:

$$B = \frac{\mu_0 I}{2\pi r}, \quad \mu_0 = 4\pi \times 10^{-7} T.m/A$$



12 Three long straight current carrying conductors 1, 2, and 3 are located perpendicular to the page, as shown above. They are carrying currents, $I_1 = 3.5$ A (coming out of the page), $I_2 = 2.5$ A (going into the page), and $I_3 = 1.5$ A (coming out of the page), as shown above. Conductors 1 and 2 are separated by 10 cm, conductors 2 and 3 are separated by 25 cm, and point P is 8.0 cm from I_3.

1. Draw the magnetic field with direction by I_3 at point P.
2. Calculate the net magnetic field (magnitude and direction) at point P due to all three currents.

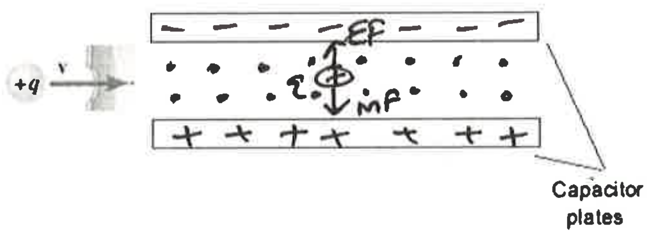
$$B_1 = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 3.5}{2\pi \times 0.43} = 1.63\ \mu T \uparrow$$

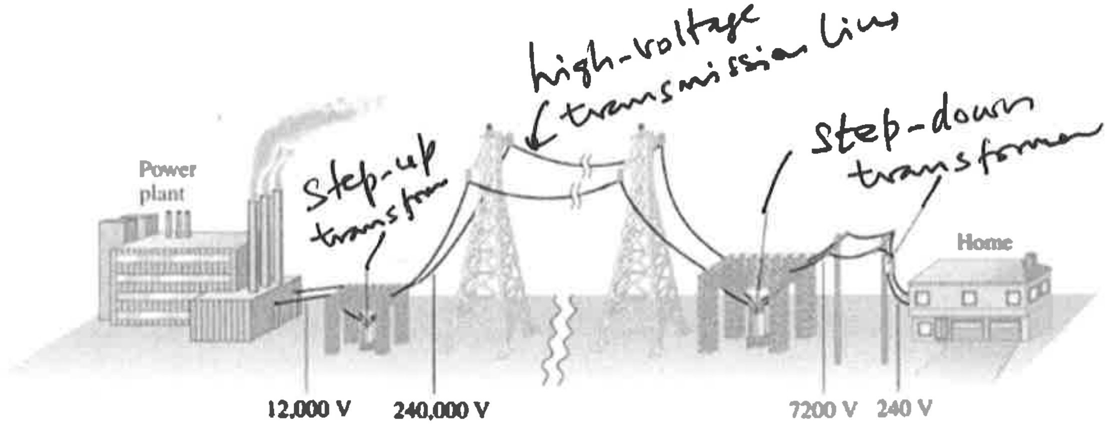
$$B_2 = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33} = 1.515\ \mu T \downarrow$$

$$B_3 = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 1.5}{2\pi \times 0.08} = 3.75\ \mu T \uparrow$$

$$B_{net} = 3.75 + 1.63 - 1.515 = 3.87\ \mu T \uparrow$$

8 C. A velocity selector is shown for positively charged particles. Between the capacitor plates, magnetic field is perpendicular and coming out of the page. Show the charges in the capacitor plates, magnetic field, magnetic force, and the electric force in the diagram, when the charge is inside the plates.





D. Power generation and transmission

1. Identify a step-down transformer, step-up transformer, and high-voltage transmission lines in the diagram above.

2. If there are 50 turns in the primary of the step-up transformer, how many turns are there in the secondary?

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} \rightarrow \frac{N_s}{50} = \frac{240{,}000}{12{,}000} = 20$$

$$N_s = 50 \times 20 = 1000$$

$$\boxed{N_s = 1000}$$

3. If 2.2 MW of power is transmitted to a town located 37 km away, how much power is lost in the transmission lines? Assume that each of the two transmission lines has a resistance per kilometer of length of $4.5 \times 10^{-2}\ \Omega/\text{km}$.

$$P = 2.2\,\text{MW} = 2.2 \times 10^6\,\text{W} = IV = I \times 240{,}000$$

$$\frac{2.2 \times 10^6}{240{,}000} = I = 9.17\,\text{A}$$

$$R = 2 \times 37 \times 4.5 \times 10^{-2}\,\Omega = 3.33\,\Omega$$

$$P_{loss} = I^2 R = 9.17^2 \times 3.33$$

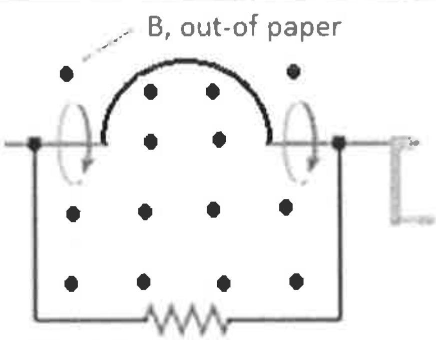
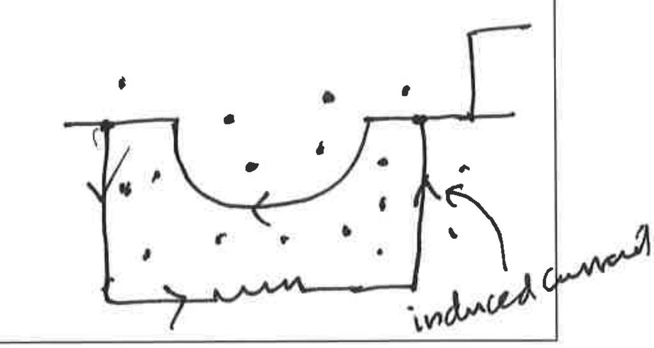
$$P_{loss} = \underline{280}\ \text{Watt}$$

4. What happens to the lost power in 3, above?

Heat ~ Thermal energy.

E. Faraday's law of induction: $\xi = -N\frac{\Delta\Phi}{\Delta t}; \Phi = B_{\perp}A.$ Ohm's law: V = IR $f = \frac{1}{T}$

A loop of wire has the initial shape shown in the drawing. The top part of the wire is bent into a semi-circle of diameter 0.30 m, which can be rotated with the handle. A constant magnetic field of magnitude 0.35 T is directed out of the paper.

Initial Shape of the loop	Shape of the loop after ½ a revolution
	

2 1. Sketch the shape of the loop in the box above when the semi-circular side is rotated through ½ of a revolution.

3 2. What is the change in magnetic flux when the semi-circular side is rotated through ½ of a revolution, starting from the position shown?

$\Delta\phi = -B_{\perp}A = -0.35 \times \pi r^2$
$= 0.35 \times \pi \times 0.15^2 = -2.47 \times 10^{-2}\ T \cdot m^2$
$= -0.0247\ T \cdot m^2$

3 3. If the above ½ of a revolution takes 4.5 ms, what is the average induced emf in the loop?

$\xi = -N \cdot \frac{\Delta\phi}{\Delta t} = -\frac{1 \cdot (-0.0247)}{4.5 \times 10^{-3}} = 5.5$ volt

3 4. If the resistance shown in the loop is 1.8 ohm, what is the induced current?

$V = IR \rightarrow I = \frac{V}{R} = \frac{5.5}{1.8} = 3.05A$

$I = 3.05A$

2 5. Show the direction of the induced current in the loop?

3 6. What is the frequency of the above rotation?

$f = \frac{1}{T} = \frac{1}{2 \times 4.5ms} = \frac{1}{9ms} = \frac{1}{0.009} = 111\ Hz$

4 7. Describe 4 ways to increase the induced current in the loop.

1. Increase the area of the half-circle
2. Rotate faster,
3. Increase the magnetic field.
4. Lower the resistance