Restroom breaks are NOT allowed during the test. If you need one, take it before starting the test.

T3 S2026 Answer Key

Internet access and Phone Use are not allowed.

Only a calculator is allowed for calculations.

Turn off your cell phone. Everything you write must be your own work.

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: $B = \frac{\mu_0 I}{2\pi r}$, $\mu_0 = 4\pi \times 10^{-7}$ (SI)

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:

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

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

$\chi_C = \frac{1}{2\pi f C}$. $\quad \chi_L = 2\pi f L.$ $\quad f = \frac{1}{T}$

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: $c = \frac{E}{B}$ $\quad c = \lambda f$

12. Circumference, C and Area, A of a circle (radius *r*): $C = 2\pi r$ $\quad A = \pi r^2$

Area of a rectangle = length x width. Area of a triangle $= \frac{1}{2} \times base \times height$

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

PHYS 202 Spring 2026 Test #3 Name: Answer Key

40
2/each

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 others.

__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:

$$F = qVB\sin\theta$$

2. Define θ, in the above equation: angle between V and B.

__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. $\frac{N.m}{C}$

$B = \frac{F}{qV} \rightarrow \frac{N}{C.\,m/s} = \frac{N.S}{C.m}$

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

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

N, W, E, S

__C__ 5. Which one of the following is a unit for electromagnetic energy?

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

__b__ 6. Who is credited for measuring the speed of light accurately for the first time?

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

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

__a__ 8. What is the angle between the centripetal acceleration and magnetic force for a charged particle moving in uniform circular motion in a magnetic field?

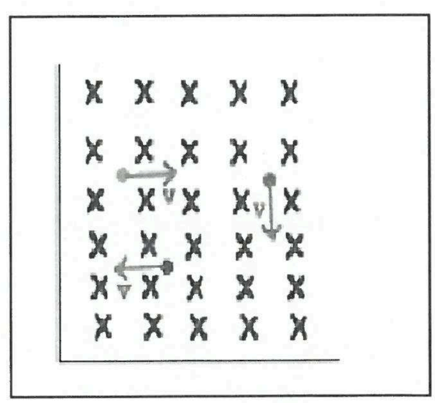
Answers for 7 & 8: a. 0^0 b. 45^0 c. 90^0 d. 120^0 e. 180^0

__b__ 9. Which one of the following is not a ferromagnetic material?

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

__D__ 10. Which one of the electromagnetic waves is used for medical imaging of the human body?

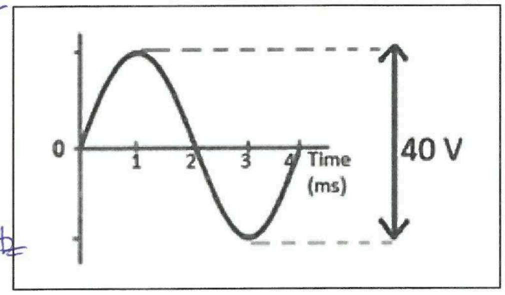
A. radio wave B. ultraviolet C. Gamma
D. X-ray E. Infrared



__a__ 11. 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 electron and moving to the left?

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

12-13) Consider the ac voltage shown to the right: $\frac{V_p}{\sqrt{2}} = \frac{20}{\sqrt{2}} =$



__c__ 12. What is the rms voltage for the ac voltage?

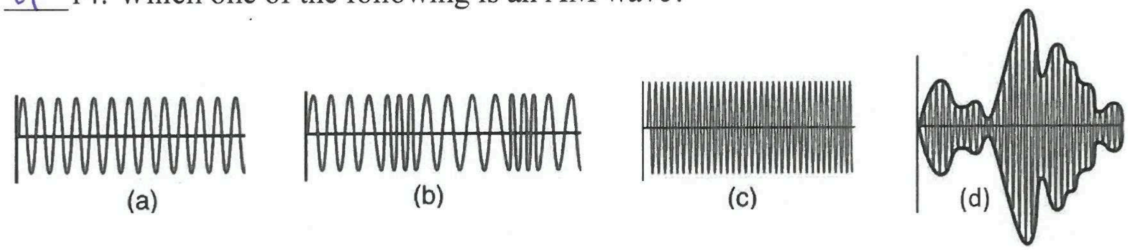
a. 7.1 V b. 10 V c. 14 V d. 40 V

__a__ 13. What is the frequency of the ac voltage?

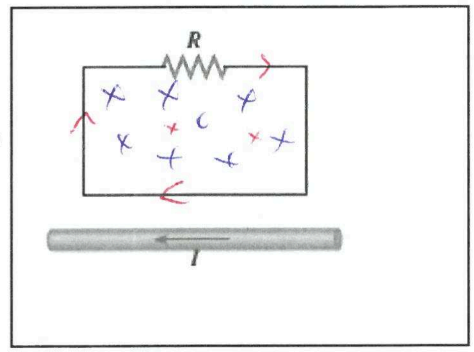
a. 250 Hz b. 500 Hz c. 750 Hz e. 1000 Hz

$T = 4ms = 0.004s \rightarrow f = \frac{1}{T} = \frac{1}{0.004} = 250\,Hz$

__d__ 14. Which one of the following is an AM wave?



15-17) 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__ 15. What is the direction of the magnetic field inside the loop?

a. coming out (·) b. going in (X)

__c__ 16. If the current *I* is constant, what is the direction of the induced current through the loop? x↓ need x

__a__ 17. If the current *I* is decreasing in time, what is the direction of the induced current through the loop?

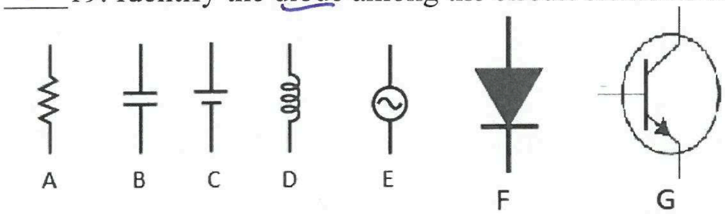
Answers for 16 & 17: a. clockwise b. counterclockwise c. no current

__d__ 18. Radio waves travel at the speed of light, 3.0×10^8 m/s. What is the wavelength of the 1000 kHz radio wave?

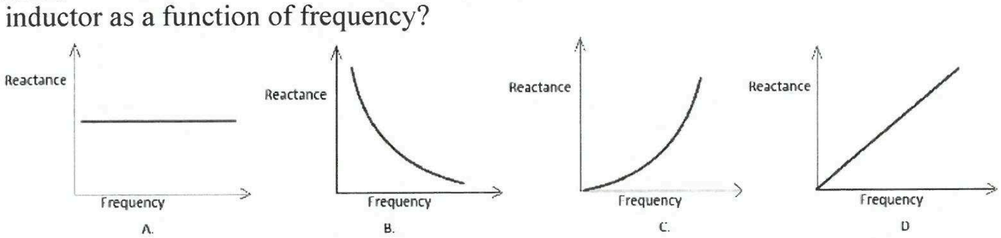
a. 0.3 m b. 3 m c. 30 m d. 300 m e. 3.0×10^5 m

$c = \lambda f$, $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{1000 \times 10^3} = 300$

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



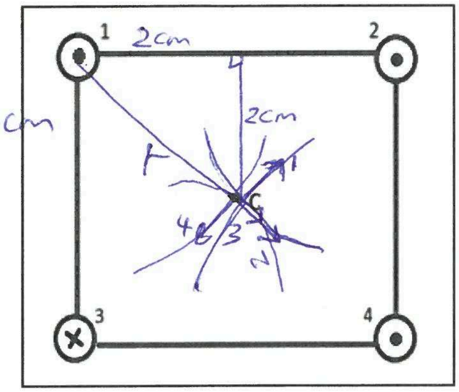
__D__ 20. Which one of the following figures correctly shows the variation of reactance of an inductor as a function of frequency?



(22)

B. Four currents of equal magnitude (3 A) are passing through 4 long conductors (1,2,3,4) located along the corners of a square (side length = 4 cm) as shown below. The currents are perpendicular to the page and the direction of current flow is either a cross (going into the page) or dot (coming out of the page). The center of the square is C.

1. Determine the perpendicular distance to C from each of the current.
2. Show the magnetic field by each of the current at C.
3. Determine the net magnetic field at C due to all four currents.



2 — 1. $r^2 = 2^2 + 2^2 = 4 + 4 = 8 \rightarrow r = \sqrt{8} = 2.83$ cm

$r = 2.83$ cm $= 0.0283$ m

4 — 2. In the diagram.

3. B_1 & B_4 are equal & opposite. They cancel each other.

4 — B_2 & B_3 will add up.

$$\text{net } B_C = B_2 + B_3 = \frac{4\pi \times 10^{-7} \times 3}{2\pi \times 0.0283} + \frac{4\pi \times 10^{-7} \times 3}{2\pi \times 0.0283} = 21.2\,\mu T + 21.2\,\mu T$$

$$\text{net } B_{at\,C} = 42.4\,\mu T = 42.4 \times 10^{-6}\,T = 4.24 \times 10^{-5}\,T$$

C. A velocity selector is shown below for negatively charged particles.

4 — 1. Show the charges in the capacitor plates, electric field (E), and the magnetic field (B) between the plates, for this to work.

3 — 2. Derive an expression for the velocity of the charged particles in terms of E and B that will move through the capacitor plates without any deflection.

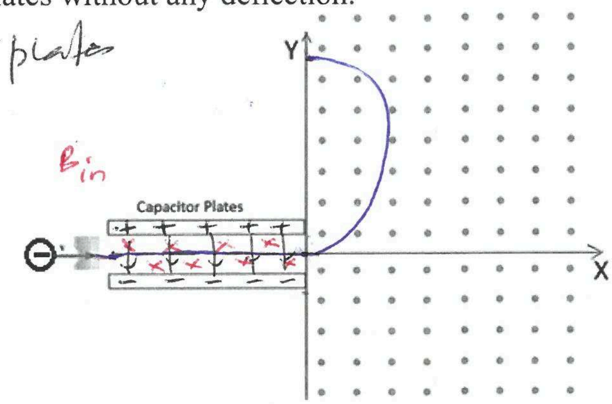
Between the capacitor plates

$F_B = F_E$

$qvB\sin\theta = qE$ ($\theta = 90$)

$qvB = qE$

$v = E/B$



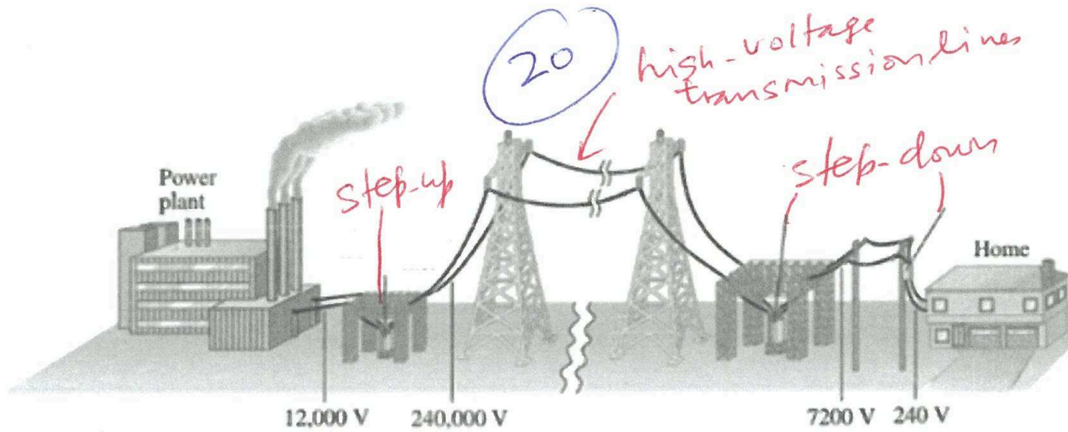
5 — 3. Show the motion of the charge particles in the magnetic field which is strong enough for the charge particles to make a semi-circle and derive an expression for the radius.

For the circular motion, $F_C = qvB\sin\theta$ ($\theta = 90$)

$\frac{mv^2}{r} = qvB$

$\frac{mv}{r} = qB$

$r = \frac{mv}{qB}$



D. Power generation and transmission

3

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

2. Describe the purpose and function of a transformer in electric power transmission to a lay person.

5

A transformer can increase or decrease the voltge, which is accomplished by using a different number of turns in the primary & secondary coils of the transformer. The linkage is provided by the magnetic field, which is the same in both sides.
High-voltage transmission lines use high-voltage, and hence small current to minimize power loss in transmission lines.

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

$N_p = 50$, $N_s = ?$ $\quad \frac{N_s}{N_p} = \frac{V_s}{V_p}$ $\quad$ $N_s = 1000$

4

$\frac{N_s}{N_p} = \frac{N_s}{50} = \frac{240,000}{12,000} \Rightarrow N_s = \frac{50 \times 240,000}{12,000} = 1000$

4. 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 4.5×10^{-2} Ω/km.

$P = IV$ $\quad$ $R = 4.5 \times 10^{-2} \times 2 \times 37$

$R = 3.33\,\Omega$

6

$2.2 \times 10^6 = I \times 240,000$ $\quad$ $P_{Loss} = I^2 R = 9.17^2 \times 3.33$

$I = \frac{2.2 \times 10^6}{240,000} = 9.17A$ $\quad$ $P_{Loss} = 280W$

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

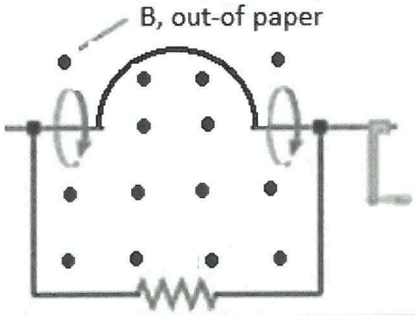
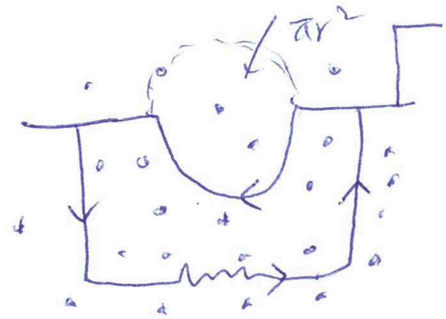
Lost as heat in the high-voltage transmission lines.

2

18

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 0.40 m, which can be rotated with the handle. A constant magnetic field of magnitude 0.45 T is directed out of the paper.

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

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

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?

3

$\Delta\phi = -B_{\perp} \cdot A = -0.45 \times \pi r^2 = -0.45 \times \pi \times 0.2^2$

$A = \pi r^2 = \pi \times 0.2^2 = 0.126\ m^2$ $\quad \Delta\phi = -0.0565\ T.m^2$

3. If the above ½ of a revolution takes 6.5 ms, what is the induced emf in the loop?

2 $\quad \mathcal{E} = -\frac{N\Delta\phi}{\Delta t} = -\left(\frac{-0.0565}{6.5 \times 10^{-3}}\right) = 8.7$ volt

4. If the resistance shown in the loop is 3.2 ohm, what is the induced current?

2 $\quad I = V/R = \frac{8.7}{3.2} = 2.7\ A$

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

2 Increase B, Increase the diameter, rotate faster, Lower the resistance.

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

2 7. What is the period and frequency of the above rotation?

$T = 2 \times 6.5\ ms = 13\ ms = 0.013\ s$

$f = \frac{1}{T} = \frac{1}{0.013} = 77\ Hz$

8. Sketch the induced emf as a function of time for 3 periods.

2