Q1.

One end of a stretched string vibrates with a period of 1.5 s. This results in a wave propagating at a speed of 8.0 m/s along the string. What is the wavelength, in m, of the wave that travel along the string?

A) 12
B) 10
C) 3.0
D) 8.0
E) 1.5

Ans:

$$\lambda = \frac{v}{f} = vT = 8 \times 1.5 = 12$$

Q2.

A pipe has two consecutive resonance frequencies of 220 Hz and 260 Hz. One end of the pipe is closed. What is the fundamental frequency of the pipe?

A) 20 Hz
B) 30 Hz
C) 40 Hz
D) 60 Hz
E) 80 Hz

Ans:

$$f_{n+2} - f_n = 2 \times \frac{V}{4L} = 260 - 220 = 40 \text{ H}_z$$

$$\Rightarrow f_1 = 1 \times \frac{V}{4L} = \frac{40}{2} \text{ H}_z = 20 \text{ H}_z$$

Q3.

At what temperature is the Fahrenheit scale reading equal to half that of the Celsius scale?

A) − 12.3 ^{o}F
B) + 23.4 ^{o}F
C) − 230 ^{o}F
D) − 40.0 ^{o}F
E) + 32.0 ^{o}F

Ans:

$T_f = T_c/2$ implies $T_c = 2\,T_f$, , then $T_f = 9/5(2T_f) + 32$ and $T_f = -12.3\ ^{o}$F

Q4.

A 0.050-m^3 container has 5.00 moles of argon gas at a pressure of 1.00 atm. What is the rms speed of the argon molecules? (M_{Ar} = 40.0 g/mole)

A) 275 m/s
B) 496 m/s
C) 398 m/s
D) 940 m/s
E) 870 m/s

Ans:

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3\frac{PV}{n}}{M}} = \sqrt{\frac{3\frac{1.01\times 10^5 \times 0.050}{5.00}}{0.040}} = 275\ m/s$$

Q5.

At very low temperatures, the molar specific heat C of aluminum is given by the relation $C = AT^3$, where A = 3.15 × 10^{-5} J/(mol.K^4). Find the entropy change for 4.00 mol of aluminum when its temperature is raised from 5.00 K to 10.0 K.

A) 0. 0368 J/K
B) 0. 0442 J/K
C) 0. 1260 J/K
D) 0. 0184 J/K
E) 0. 0034 J/K

Ans:

$$\Delta S = \int \frac{nC_V\, dT}{T} = nA\int_{5.00}^{10.0} T^2 dT = \frac{nA}{3}\left[(10.0)^3 - (5.00)^3\right] = 0.0368 \text{ J/K.}$$

Q6.

Two identical conducting spheres, each having a radius of 0.500 cm, are connected by a light 2.00-m-long conducting wire. A charge of 60.0 μC is placed on one of the conductors. Assume that the surface distribution of charge on each sphere is uniform. Determine the tension in the wire.

A) 2.00 N
B) 3.00 N
C) 1.00 N
D) 0.50 N
E) 6.00 N

Ans:

The charges on the charged conducting sphere are mobile. The charges will then flow through the conducting wire from the charged sphere to the uncharged conducting sphere. The charge flow will continue until the total charge is divided equally among the two identical spheres. Now, the two sphere are charged with similar charge Q/2, so they repel each other, like point charges at their centers, extending the wire and putting it under tension. The tension in the wire is then determined by the Coulomb force of repulsion between the spheres, i.e.

$$T = F_E = k_e \frac{q_1 q_2}{r^2} = k_e \frac{(Q/2) \times (Q/2)}{(L + 2R)^2} = k_e \frac{Q^2}{(L + 2R)^2}$$

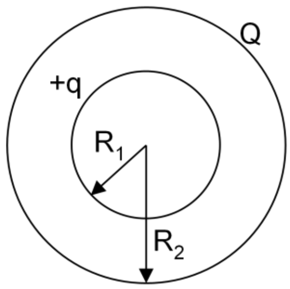
And

$$T = 8.99 \times 10^9 \frac{(60.0 \times 10^{-6})^2}{4 \times (2.00 + 0.01)^2} = 2.00\ N$$

Q7.

Figure 1 shows two concentric conducting shells of radii (R_1=2.0 cm) and (R_2=6.0 cm). The smaller (inner) shell has a net positive charge (+q) and the larger (outer) shell has a net charge of magnitude Q. If the electric potential on the inner shell (r = R_1) is zero, what is the value of the ratio Q/q?

Figure 1



A) − 3.0
B) − 0.33
C) + 3.0
D) + 0.33
E) − 9.0

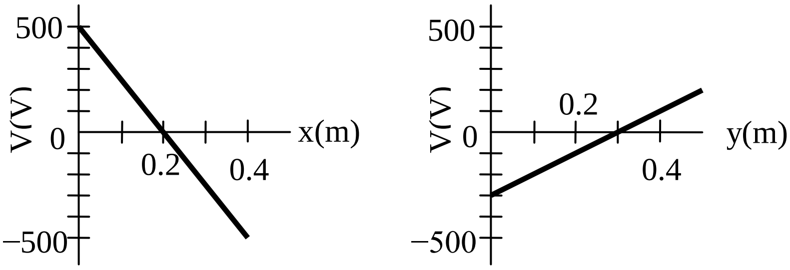
Ans:

$$V(r = R_1) = kQ/R_2 + kq/R_1 = 0 \rightarrow Q/q = -R_2/R_1 = -6/2 = -3.0$$

Q8.

In xy-plane, the electric potential depends on *x* and *y* as shown in **Figure 2** (the potential does not depend on z). The electric field in this region is:
[$\hat{i}$ and $\hat{j}$ are the unit vectors in x and y direction, respectively]

Figure 2



A) $(+2500\,\hat{i} - 1000\,\hat{j})$ V/m
B) $(+500\,\hat{i} - 500\,\hat{j})$ V/m
C) $(-500\,\hat{i} + 1000\,\hat{j})$ V/m
D) $(-500\,\hat{i} + 500\,\hat{j})$ V/m
E) $(+5000\,\hat{i} - 2000\,\hat{j})$ V/m

Ans:

$$E_x = -\frac{\partial V}{\partial x} = -\frac{(0-500)}{(2-0)} = 2500\ \text{i}.$$

$$E_y = -\frac{\partial V}{\partial y} = -\frac{(0-(-300))}{(3-0)} = -1000\ \text{j}.$$

Q9.

If we make two conducting spheres to touch each other (see **Figure 3**), then find the final charges of the spheres.

A) A = +10q , B = +5q
B) A = +15q , B = +5q
C) A = −5q , B = +20q
D) A = −10q , B = +5q
E) A = −5q , B = −5q

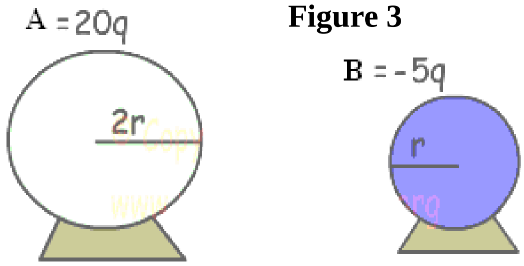


Figure 3

Ans:

Charge per unit radius is found:
$q_r=(Q_1+Q_2)/(r_1+r_2)$

$q_r=(20-5)q/(2r+r)=5q/r$

Charge of first sphere becomes:

$Q_1=q_r.r_1=(5q/r).2r=10q$

Charge of second sphere becomes:

$Q_2=q_r.r_2=(5q/r).r=5q$

Q10.

A 500-nF capacitor, C_1, is fully charged by a 120-V power supply, then disconnected. Next, the capacitor C_1 is connected to an initially uncharged capacitor C_2. Find the capacitance of C_2 if the potential difference across it is found to be 50.0 V.

A) 700 nF.
B) 170 nF.
C) 210 nF.
D) 480 nF.
E) 600 μF.

Ans:

Total charge Q_i initially on $C_1 = C_1 V_i = (500\times10^{-9})(120) = 6.00\times10^{-5}$ C.

After disconnecting the power supply and connecting C_1 to C_2 the charge Q will distribute among the two capacitors such that they have the same potential difference across them because they are in parallel and sum of the charges on them is equal to the initial charge due to conservation of charges.

Then $V_1 = V_2 = V$ and $Q_i = Q_1 + Q_2 = C_1V_1 + C_2V_2 = (C_1 + C_2)V$

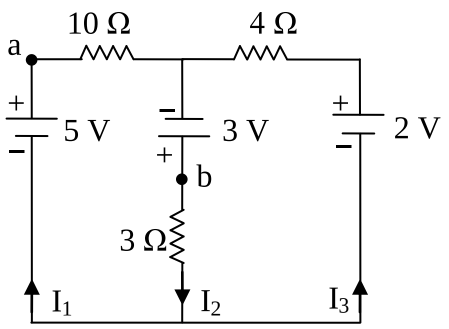
➔ $C_2 = (Q_i / V) - C_1$

$C_2 = (Q_i / V) - C_1 = (6.00\times10^{-5})/(50.0) - 500\times10^{-9} = 7.00\times10^{-9}$ F = 700 nF

Q11.

In **Figure 4**, the currents I_1 and I_2 are 0.14 A and 2.22 A, respectively, what is the potential difference V_a-V_b?

Figure 4



A) −1.6 V
B) 0 V
C) +3.0 V
D) −3.0 V
E) +1.6 V

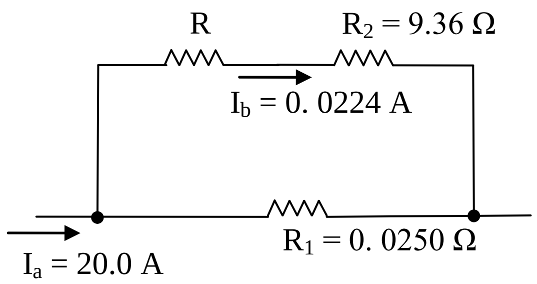
Ans:

$$V_a - V_b = 10I_1 - 3 = -1.6V$$

Q12.

In **Figure 5**, find the resistance R,

Figure 5



A) 12.9 Ω
B) 10.0 Ω
C) 16.2 Ω
D) 14.3 Ω
E) 18.8 Ω

Ans:

$$I_b(R + R_2) = (I_a - I_b)R_1$$

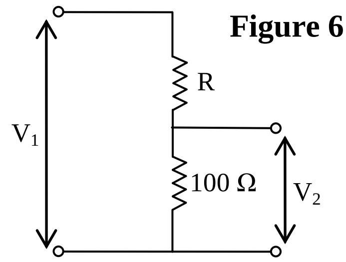
$$Where, I_b = 0.0224;\ R_2 = 9.36;\ \ I_a = 20;\ R_1 = 0.025$$

Solving, we get resistance R = 12.9 Ω

Q13.

What value of R will make $V_2=V_1/10$ in the circuit in **Figure 6**?

Figure 6



A) 900 Ω
B) 200 Ω
C) 100 Ω
D) 700 Ω
E) 500 Ω

Ans:

$$V_1 = I(R+100) \rightarrow I = \frac{V_1}{R+100},$$
$$V_2 = 100I \rightarrow I = \frac{V_2}{100} = \frac{V_1}{R+100} \rightarrow \frac{V_2}{V_1} = \frac{100}{R+100} = \frac{1}{10}$$

$R = 1000 - 100 = 900$

Q14.

Three identical resistors are connected in series. When a certain potential difference is applied across the combination, the total power dissipated is 36.0 W. What power would be dissipated if the three resistors were connected in parallel across the same potential difference?

A) 324 W
B) 124 W
C) 36.0 W
D) 6.00 W
E) 423 W

Ans:

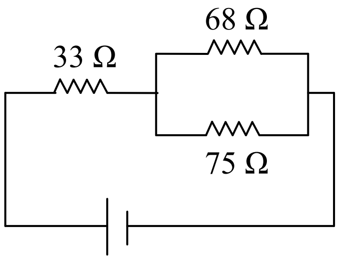
$$P_p = \frac{V^2}{R_p} = \frac{V^2}{R/3}, P_s = \frac{V^2}{R_s} = \frac{V^2}{3R} = \frac{V^2/9}{3R/9} = \frac{1}{9}\frac{V^2}{R/3} = \frac{1}{9}P_p$$

$$P_p = 9\,P_s = 9 \times 36 = 324\,W$$

Q15.

In the circuit shown in **Figure 7**, the 33Ω resistor dissipates 0.50 W. What is the emf of the ideal battery?

Figure 7



A) 8.5 V
B) 7.1 V
C) 3.5 V
D) 1.3 V
E) 5.9 V

Ans:

$$P = I^2R \rightarrow I = \sqrt{\frac{P_{33}}{R_{33}}} = 0.123A, R_{eq} = 33 + (\frac{1}{68} + \frac{1}{75})^{-1} = 68.88\Omega,$$

$$V = IR_{eq} = 8.5V$$

Q16.

A charged capacitor, with potential difference12.0 V is connected to a voltmeter having an internal resistance of 3.4×10^6 Ω. After a time of 4.0 s the voltmeter reads 3.0 V. What is the capacitance of the capacitor?

A) 8.5×10^{-7} F
B) 3.4×10^{-7} F
C) 2.8×10^{-4} F
D) 6.3×10^{-4} F
E) 1.2×10^{-4} F

Ans:

$$V = V_o e^{-t/RC}$$

$$3 = 12e^{-\frac{4}{3.4\times10^6}\mathrm{C}}$$

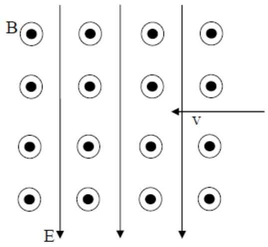
$$l_n\left(\frac{1}{4}\right) = -\frac{4}{3.4\times10^6\mathrm{C}} = -l_n 4$$

$$C = \frac{4}{3.4\times10^6 l_n 4} = 8.5\times10^{-7}F$$

Q17.

Figure 8 shows a region where there is a uniform electric field and a uniform magnetic field normal to each other. A proton is moving to the left with speed "v" in the plane of the page. If v is increased in such a way that v > E/B, the proton will (Neglect the gravity)

Figure 8



A) stay in the plane of the page and deflect upward
B) undergo no deflection
C) deflect out of the plane of the page
D) stay in the plane of the page and deflect downward
E) stop

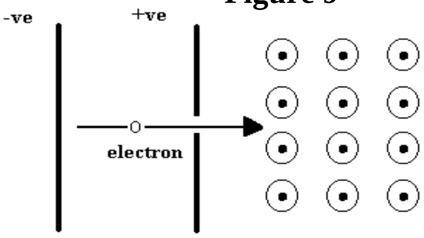
Ans:

A

Q18.

Figure 9 shows an electron entering a magnetic field with a speed of 5.5×10^6m/s. The magnetic field has a magnitude of 0.75 T. Calculate the radius of the electron's circular path, in micro-meter.

Figure 9



A) 42
B) 53
C) 82
D) 11
E) 19

Ans:

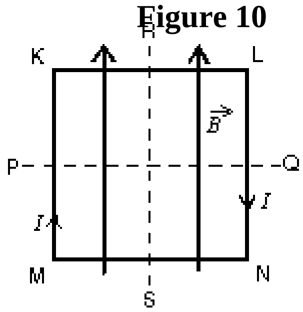
$q_e = 1.6\times10^{-19}; v = 5.5\times10^6; B = 0.75;\ m_e = 9.11\times10^{-31}$

$$r = \frac{\frac{m_e v}{q_e B}}{10^{-6}} = 41.7542 = 42$$

Q19.

A square loop of wire lies in the plane of the page and carries a current I as shown in **Figure 10**. There is a uniform magnetic field $\vec{B}$ directed towards the top of the page, as indicated. The loop will tend to rotate:

Figure 10



A) about PQ with KL coming out of the page
B) about PQ with KL going into the page
C) about RS with MK coming out of the page
D) about RS with MK going into the page
E) about an axis perpendicular to the page

Ans:

A

Q20.

A loop of current-carrying wire has a magnetic dipole moment of 5.0×10^{-4} A.m^2. If the dipole moment makes an angle of 57° with a magnetic field of 0.35 T, what is its orientation energy?

A) -9.5×10^{-5} J
B) -1.5×10^{-4} J
C) -1.8×10^{-4} J
D) $+1.5 \times 10^{-4}$ J
E) $+9.5 \times 10^{-5}$ J

Ans:

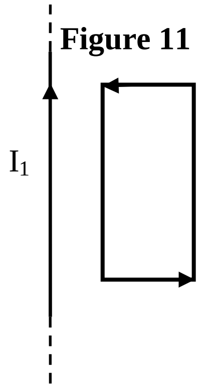
$$U(\theta) = -\vec{\mu} \cdot \vec{B}$$

$$U = -5.0 \times 10^{-4} \times 0.35 \times \cos 57° = -9.5 \times 10^{-5} J$$

Q21.

A rectangular current carrying loop is shown in **Figure 11** beside a long straight current carrying wire. Which one of the following statements could be responsible for the current direction shown in the loop?

Figure 11



A) The loop is moving to the left
B) The loop is moving to the right
C) The loop is moving up the page
D) The loop is moving down the page
E) The loop must remain motionless

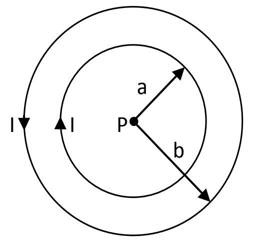
Ans:

A

Q22.

Two concentric circular loops of wire of radii a = 2.0 cm and b = 4.0 cm each carries a current I = 5.00 A in the directions indicated in **Figure 12**. What is the magnetic field at center P?

Figure 12



A) 78.5 μT into the page
B) 78.5 μT out of the page
C) 29.3 μT into the page
D) 29.3 μT out of the page
E) 0.60 μT into the page

Ans:

$$B=\frac{\mu_o I}{4\pi R}\varphi=\frac{\mu_o I}{4\pi}\left(\frac{1}{a}-\frac{1}{b}\right)\varphi=\frac{4\pi 10^{-7}\times 5}{4\pi}\left(\frac{1}{2/100}-\frac{1}{4/100}\right)(2\pi)$$

$$\mu_0=4\pi 10^{-7}; a=\frac{2}{100}; b=\frac{4}{100}\ ;\ I_i=5$$

$$B=\frac{\frac{\mu_{0I_i}}{4\pi}\left(\frac{1}{a}-\frac{1}{b}\right)(2\pi)}{10^{-6}}=78.5398$$

Q23.

Solenoid 2 has four times the radius and twice the number of turns per unit length as solenoid 1. Find the ratio of the magnitude of the magnetic field in the interior of solenoid 2 to that in the interior of solenoid 1, if the two solenoids carry the same current.

A) 2
B) 4
C) 6
D) 1
E) 1/3

Ans:

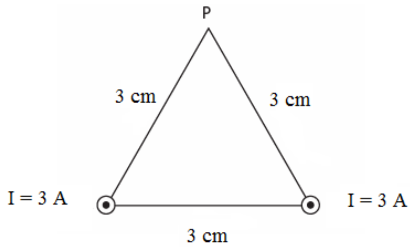
$$\frac{N_2}{L}=2\frac{N_1}{L}\ ;\ B_1=\mu_0 i\frac{N_1}{L}\ ;\ B_2=\mu_0 i\frac{N_2}{L}$$

$$\frac{B_2}{B_1}=\frac{\mu_0 i\frac{N_2}{L}}{\mu_0 i\frac{N_1}{L}}=\frac{N_2}{N_1}=2$$

Q24.

Two long straight wires penetrate, normally, the plane of the paper at two vertices of an equilateral triangle as shown in **Figure 13**. They each carry 3.0 A, out of the page. The magnetic field at the third vertex (P) has magnitude (in T):

Figure 13



A) 3.5×10^{-5}
B) 2.0×10^{-4}
C) 0
D) 3.5×10^{-7}
E) 8.7×10^{-6}

Ans:

$$B = \frac{2\mu_0 \times i \times cos(30)}{2\pi \times R} = \frac{2 \times 1.26 \times 10^{-6} \times 3 \times 0.866}{2\pi \times 0.03}$$

$$B = 3.47\ 10^{-5}\ T$$

Q25.

A long wire has a radius R > 4.0 mm and carries a current that is uniformly distributed over its cross section. The magnitude of the magnetic field due to this current is 0.28 mT at a point 4.0 mm from the axis of the wire, and 0.20 mT at a point outside the wire and at 10 mm from the axis of the wire. What is the radius R of the wire?

A) 5.3 mm
B) 6.0 mm
C) 7.5 mm
D) 8.0 mm
E) 4.6 mm

Ans:

$$B_{out} = \frac{\mu_o I}{2\pi r_2}; \quad B_{in} = \frac{\mu_o I r_1}{2\pi R^2} \quad \Rightarrow R = \sqrt{r_2 r_1 \frac{B_{out}}{B_{in}}}$$

$$B_{in} = 0.28 \times 10^{-3};\ B_{out} = 0.2 \times 10^{-3};\ \ r_1 = 4 \times 10^{-3};\ r_2 = 10 \times 10^{-3}$$

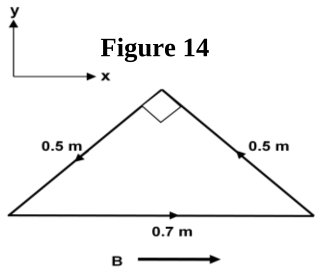
$$R = \frac{\sqrt{r_1 r_2 \frac{B_{out}}{B_{in}}}}{10^{-3}} = 5.34522$$

Q26.

A current loop, carrying a current of 2.0 A, is in the shape of a right angle triangle with sides 0.5, 0.5, and 0.7 m as shown in **Figure 14**. The loop is in a uniform magnetic field of magnitude 120 mT whose direction is parallel to the current in the 0.7 m side of the loop. Find the magnitude of the torque, in N.m, on the loop.

A) 0.03
B) 12
C) 24
D) 0.06
E) 0

Figure 14



Ans:

a=The area for triangle is 2500/2 cm^2, or 0.125 m^2.

μ=the dipole moment is (2.0 A)(0.125 m^2) = 0.25 A-m^2 and out of the page.

τ=The torque is thus (0.250 A-m^2)(0.120 T) sin(90) = 0.03 N·m

---

Q27.

A uniform magnetic field B = 2.0 T makes an angle of 30^o with the z – axis. The magnitude of the magnetic flux through a 3.0 m^2 portion of the x-y plane is:

A) 5.2 Wb
B) 2.0 Wb
C) 3.0 Wb
D) 6.0 Wb
E) 9.0 Wb

Ans:

$$\Phi = BA\cos\theta = 2.0 \times 3.0 \times cos30° = 6 \times 0.866 = 5.196\,Wb$$

Q28.

The plane of a rectangular coil of dimensions 5.0 cm by 8.0 cm is perpendicular to the direction of a magnetic field $\vec{B}$. If the coil has 75 turns and a total resistance of 8.0 Ω, at what rate must the magnitude of $\vec{B}$ change in order to induce a current of 0.10 A in the windings of the coil?

A) 2.67 T/s
B) 3.33 T/s
C) 0.63 T/s
D) 1.45 T/s
E) 8.32 T/s

Ans:

$$|\varepsilon| = NA\frac{dB}{dt} \Rightarrow i = \frac{|\varepsilon|}{R} = \frac{NA\left(\frac{dB}{dt}\right)}{R}$$

$$\therefore \frac{dB}{dt} = \frac{Ri}{NA} = \frac{8 \times 0.10}{75 \times 40 \times 10^{-4}} = 2.67\,T/s$$

Q29.

The graph (in **Figure 15**) gives the magnitude $B(t)$ of a uniform magnetic field that exists throughout a conducting loop, with the direction of the field perpendicular to the plane of the loop. Rank the four regions of the graph according to the magnitude of the emf induced in the loop, smallest first.

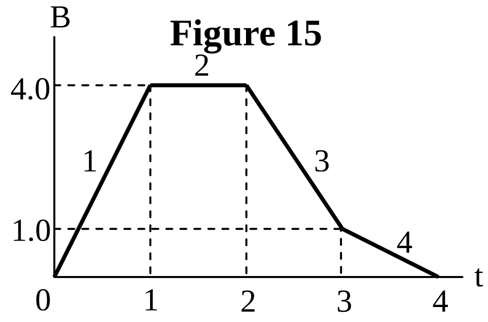


Figure 15

A) 2, 4, 3, 1
B) 1, 3, 4, 2
C) 1, 2, 3, 4
D) 4, 3, 1, 2
E) 4, 3, 2, 1

Ans:

$$\varepsilon = \left|\frac{\partial B}{\partial t}\right|$$

Q30.

A 20.0 m long copper wire, with a resistance of 10.0 Ω, is formed into a circular loop (single turn) and placed with its plane perpendicular to an external magnetic field that is increasing at the constant rate of 5.00 mT/s. At what rate is thermal energy generated in the loop?

A) 2.53 mW
B) 3.20 mW
C) 4.35 mW
D) 1.50 mW
E) 10.0 mW

Ans:

$$2\pi r = 20 \Rightarrow r = 10/\pi = 3.182 \text{ m.}$$

$$\text{A}=\pi \text{r}^2 = 100/\pi = 31.83 \text{ m}^2.$$

$$\varepsilon = A\frac{dB}{dt} \Rightarrow P = \frac{\varepsilon^2}{R}$$

$$P = \frac{A^2\left(\frac{dB}{dt}\right)^2}{R}$$

$$= \frac{(31.83)^2(5\times10^{-3})^2}{10}$$

$$= 2532.7\times10^{-6} = 2.53 \text{ mW}$$
