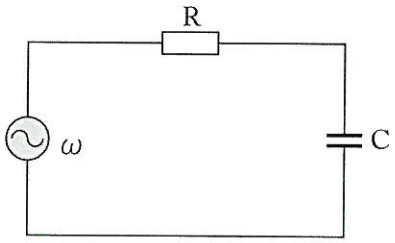
Student 6
Average 30.8/50
Best 47.0/50

12th Physics (2018 – 19)

(4thQ, #1 Mini Test) 5-19-2019

Class	No.	Name Solutions



In a calculation problem, describe equations clearly and systematically enough to show how to solve the problem. If not enough, you won't get any points.

4 pt/question x 13 questions = 52 pt Max 50 pt

／[Total 50 pt]

Physics Constants

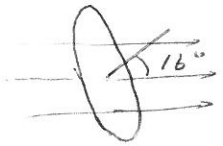
The speed of light in vacuum	$c = 2.998 \times 10^8$ m/s
Gravitational acceleration rate	$g = 9.80$ m/s^2
Universal Gravitational Constant	$G = 6.674 \times 10^{-11}$ N · m^2/kg^2
Volume of a sphere	$V = \frac{4}{3}\pi r^3$
Pi	$\pi = 3.1416$
Avogadro's Number	$N_A = 6.022 \times 10^{23}$ mol^{-1}
Coulomb's Law constant	$k = 8.988 \times 10^9$ N · m^2/C^2
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N · m^2)
Elementary Charge	$e = 1.602 \times 10^{-19}$ C
Electron mass	$m_e = 9.109 \times 10^{-31}$ kg
Proton mass	$m_p = 1.673 \times 10^{-27}$ kg
Neutron Mass	$m_n = 1.675 \times 10^{-27}$ kg

5/19/2019 By Tohei Moritani

Keio Academy of New York

Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ T·m/A

(1) A 0.055-T magnetic field passes through a circular ring of radius 3.1 cm at an angle of 16° with the normal. Find the magnitude of the magnetic flux through the ring.
(Equations)



$A = \pi r^2$

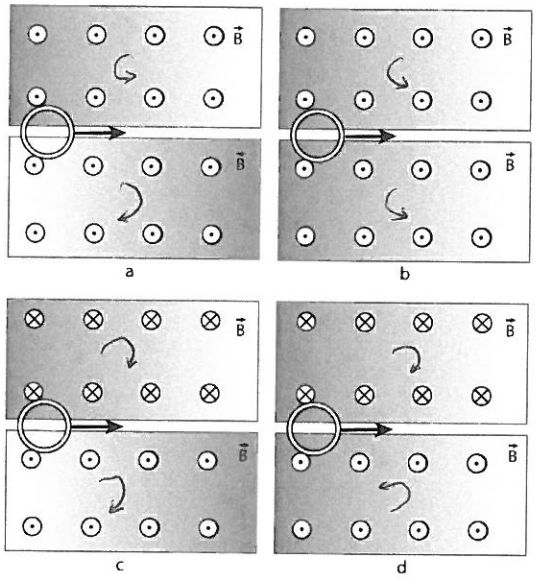
$\Phi = BA\cos\theta$

$= 0.055 \times \pi \times (0.031)^2 \cos 16^\circ$

$= 1.60 \times 10^{-4} \rightarrow 1.6 \times 10^{-4}\ [T \cdot m^2]$

(1) Answer
1.6×10^{-4} $T \cdot m^2$

(2) The figure shows four different situations in which a metal ring moves to the right with constant speed through a region with a varying magnetic field. The intensity of the color indicates the intensity of the field, and in each case the field either increases or decreases at a uniform rate from the left edge of the colored region to the right edge. The direction of the field in each region is indicated. For each of the cases, state whether the induced emf is clockwise (CW), counterclockwise (CCW), or zero (NF).



(2-a) Answer
NF

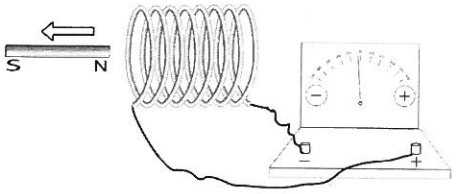
(2-b) Answer
CCW

(2-c) Answer
CW

(2-d) Answer
NF

(3-a) When the magnet is moved as shown, the galvanometer shows a swing to the positive or negative side. Answer "positive" (+) or "negative" (–).

(3-a)

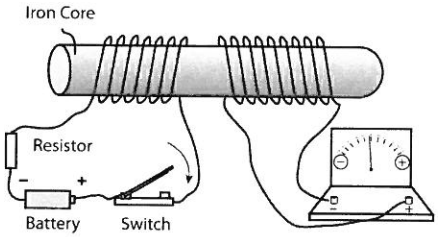


(16-b)

(14-a) Answer

+

(3-b) The instance the current is applied in the coil at the left, the galvanometer shows a swing to the positive or negative side. Answer "positive" (+) or "negative" (–).

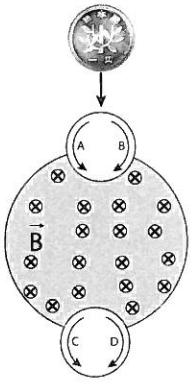


(3-b)

(3-b) Answer

+

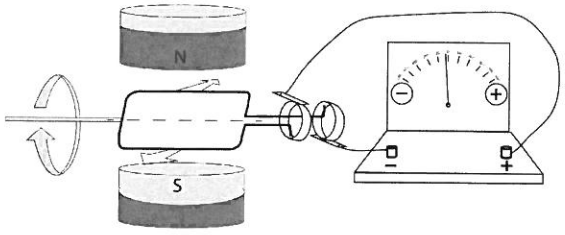
(3-c) A one yen coin slides down onto a magnet where the N pole directs upside. When the coin passes through the upper edge and lower edge, a current flows inside the coin. Predict the directions. Answer two directions from A to D.



(3-c) Answer

A and D

(3-d) The figures show generators. The coil rotates around the rotating rod in the direction shown. the galvanometer shows a swing to the positive or negative side. Answer "positive" (+) or "negative" (–).

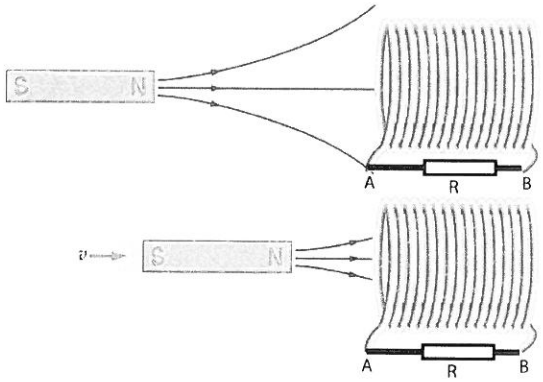


(3-d)

(3-d) Answer

+

(4) A bar magnet is moved rapidly toward a 55-loop coil of wire. As the magnet moves, the magnetic flux through the coil increases from 2.8×10^{-5} T · m² to 5.1×10^{-3} T · m² in 2.1s. The 4.6 Ω-resistance is connected to the coil as shown in the figure.



(4-a) What is the magnitude of induced emf?

(4-b) What is the magnitude and direction flowing the resistance? of the current

(a) $V = N\left|\frac{\Delta\Phi}{\Delta t}\right|$

$= 55\left|\frac{510\times10^{-3} - 2.8\times10^{-3}}{2.1}\right|$

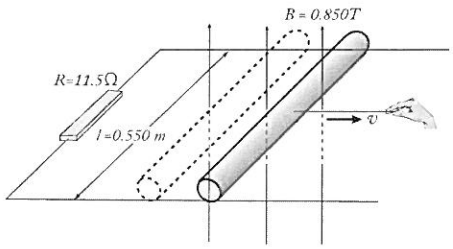
$= 0.133 \rightarrow 0.13$ [V]

(b) $i = \frac{V}{R} = \frac{0.133}{4.6} = 0.0289 \rightarrow 0.029$ [A]

Direction B → A

(4-a) Answer	0.13 V
(4-b) Answer	0.029 A B → A

(5, 6) The figure shows a zero-resistance rod sliding to the right on two zero-resistance rails separated by the distance $l = 0.550$ m. The rails are connected by a 11.5 Ω resistor, and the entire system is perpendicular to a uniform magnetic field with a magnitude of 0.750 T.



(5-a) Find the speed at which the bar must be moved to produce a current of 0.155 A in the resistor.

(5-b) Find the force that must be exerted on the rod to maintain a constant of 0.155 A in the resistor.

(6-c) What is the rate of energy dissipation in the resistor?

(6-d) What is the mechanical power delivered to the rod?

(Equations)

$$V = IR = 0.155 \times 11.5 = 1.7825$$

(a) $$V = \frac{\Delta\Phi}{\Delta t} = \frac{B\Delta A}{\Delta t} = \frac{B l \Delta x}{\Delta t} = B v l$$

$$v = \frac{V}{Bl} = \frac{1.7825}{0.85 \times 0.55} = 3.8128 \longrightarrow 3.81 \ [m/s]$$

(b) $$F = IlB = 0.155 \times 0.55 \times 0.85$$

$$= 0.07246 \ [N] \longrightarrow 0.0725 \ [N]$$

(c) $$P = VI = 1.7825 \times 0.155$$

$$= 0.2763 \longrightarrow 0.276 \ [W]$$

(d) $$P = Fv$$

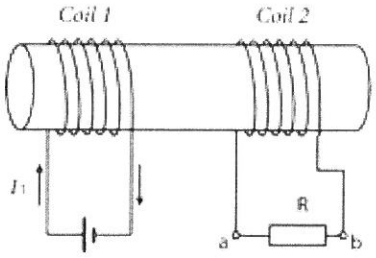
$$= 0.06394 \times 4.321$$

$$= 0.2763 \longrightarrow 0.276 \ [W]$$

(5-a) Answer	3.81 m/s
(5-b) Answer	7.25×10^{-2} N

(6-c) Answer	0.276 W
(6-d) Answer	0.276 W

(7) While the current flowing in the direction of I_1 in Coil-1 increases at the rate of 3.5 A every second, an emf of 6.8 V is produced in Coil-2.
(7-a) Find the mutual inductance between the two coils.
(7-b) Find the direction of the current between a and b.



(Equations)

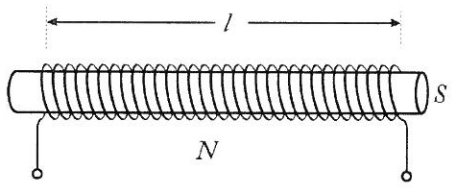
(a) $V = M\left|\frac{\Delta I}{\Delta t}\right|$

$\rightarrow M = \frac{V}{\left|\frac{\Delta I}{\Delta t}\right|} = \frac{6.8}{3.5} = 1.94 \rightarrow 1.9$ [H]

(b) a → b

(7-a) Answer
1.9 H
(7-b) Answer
a → b

(8) The inductance of a solenoid with 450 turns and a length of 24 cm is 7.3 mH.
(8-a) What is the cross-sectional area of the solenoid?
(8-b) What is the induced emf in the solenoid if its current drops from 3.2 A to 0 in 55 ms?



(a) $V = N\frac{\Delta\phi}{\Delta t} = L\frac{\Delta I}{\Delta t}$

$\rightarrow L = \frac{N\Delta\phi}{\Delta I} = N\cdot\frac{BA}{I}$ — ①

$B = \mu_0\frac{N}{\ell}I$ — ②

$\rightarrow L = N\cdot\frac{A}{I}\cdot\mu_0\frac{N}{\ell}I = \mu_0 A\frac{N^2}{\ell}$

$\therefore A = \frac{L\cdot\ell}{\mu_0 N^2} = \frac{7.3\times10^{-3}\times0.24}{4\pi\times10^{-7}\times450^2} = 6.88\times10^{-7}\times10^{7}\times10^{-3} = 6.88\times10^{-3}\ m^2$

$\rightarrow 6.9\times10^{-3}\ m^2$

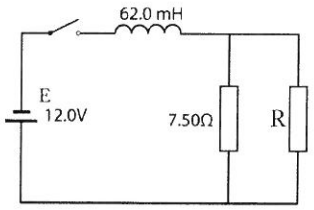
(b) $V = L\left|\frac{\Delta I}{\Delta t}\right| = 7.3\times10^{-3}\times\left|\frac{0-3.2}{55\times10^{-3}}\right|$

$= 0.4247$ (V)

$\rightarrow 0.42$ (V)

(8-a) Answer
$6.9\times10^{-3}\ m^2$
(8-b) Answer
0.42 V

(9) After the switch in the circuit shown has been closed a long time, the energy stored in the inductor is 0.110 J. What is the value of the resistance R?



Equations

$$U = \frac{1}{2} L I^2$$

$$\rightarrow I = \sqrt{\frac{2U}{L}} = \sqrt{\frac{2 \times 0.110}{62.0 \times 10^{-3}}} = 1.8837$$

$$R' = \frac{E}{I} = \frac{12.0}{1.8837} = 6.370 \ [\Omega]$$

$$\frac{1}{R'} = \frac{1}{7.50} + \frac{1}{R} \rightarrow \frac{1}{R} = \frac{1}{6.370} - \frac{1}{7.50} = 0.02364$$

$$R = 42.30 \longrightarrow 42.3 \ [\Omega]$$

(9) Answer

42.3 Ω

(10) The electric motor in a toy train requires a voltage of 3.0 V. Find the ratio of turns on the primary coil to turns on the secondary coil in a transformer that will step the 110-V household voltage down to 3.0 V.

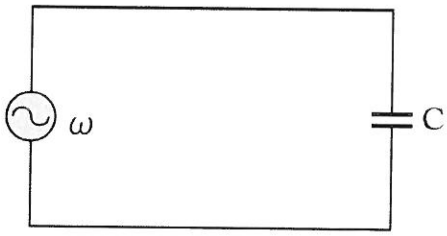
$$\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{110}{3.0} = 36.7$$

$$\longrightarrow 37$$

(10) Answer

37

(11, 12) The maximum current in a 23-μ F capacitor connected to an AC generator with a frequency of 120 Hz is 0.17 A.



(11) What is the ~~maximum~~ rms voltage of the generator?

(12) What is the voltage across the capacitor when the current in the circuit is 0.12 A and decreasing?
(Equations)

(11) $I_{max} = 0.17\ A$, $f = 120\ Hz$

$C = 23 \times 10^{-6}\ F$

$X_c = \frac{1}{2\pi f C}$ $\quad V_{max} = I_{max} \cdot X_c = \frac{0.17}{2\pi \times 120 \times 23 \times 10^{-6}}$

$= 9.802$ ~~$\rightarrow 9.8\ [V]$~~

$V_{rms} = \frac{1}{\sqrt{2}} V_{max} = 6.93 \rightarrow 6.9\ V$

(11) Answer ~~9 V~~ 6.9 V

(12) $I = I_{max} \sin\theta$

$\theta = \sin^{-1}\left(\frac{I}{I_{max}}\right) =$

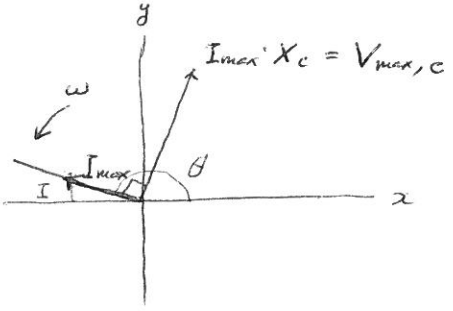
$= \sin^{-1}\left(\frac{0.12}{0.17}\right) = 44.90^\circ$

$180^\circ - 44.90^\circ = 135.10^\circ$

$V = V_{max} \sin(\theta - 90^\circ)$

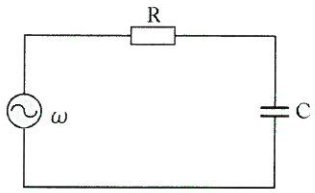
$= 9.802 \sin(45.10^\circ)$

$= 6.94 \rightarrow 6.9\ [V]$



(12) Answer 6.9 V

(13) An AC generator with an rms voltage of 120 V and the frequency of 60.0 Hz is connected in series with 32.2 μF capacitor and a resistor of 150 Ω.



(13-a) Sketch the phasor diagram for the circuit.

(13-b) What is the average power consumed by the circuit?

(Equations)

$$X_C = \frac{1}{2\pi f C}$$

$$= \frac{1}{2\pi \times 60.0 \times 32.2 \times 10^{-6}}$$

$$= 82.368 \quad [\Omega]$$

~~$V_{max\cdot R} = X_C \cdot R = 82.368 \times 150$~~

~~$= 1.24 \times 10^4$~~

$$Z = \sqrt{R^2 + X_C^2}$$

$$= \sqrt{150^2 + 82.368^2} = 171.13$$

$$I_{rms} = \frac{V_{rms}}{Z} = 0.7012 \text{ A}$$

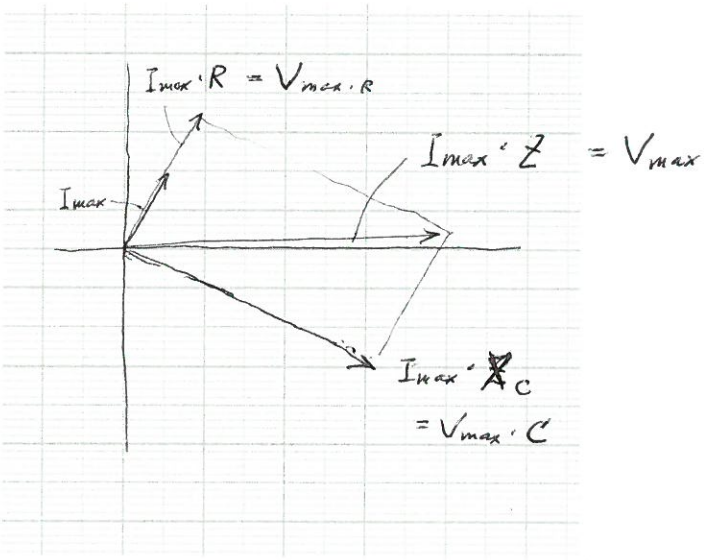
$$I_{max} = \sqrt{2} \times 0.7012 = 0.9917 \text{ A}$$

$$\cos\phi = \frac{R}{Z} = \frac{150}{171.13} = 0.87653$$

$$P_{av} = V_{rms} I_{rms} \cos\phi$$

$$= 120 \times 0.7012 \times 0.87653$$

$$= 78.75 \longrightarrow 78.8 \text{ W}$$



(13-a) Answer
Sketch it.
(13-b) Answer
78.8 W