AP Physics C: Electricity and Magnetism Practice Test 2

PHYSICS C

Physics C has two exams: Physics C (Mechanics) and Physics C (Electricity and Magnetism):

	Physics C (Mechanics)	Physics C (Electricity and Magnetism)
First 45 min.	Sec. I, Multiple Choice 35 questions	Sec. I, Multiple Choice 35 questions
Second 45 min.	Sec. II, Free Response 3 questions	Sec. II, Free Response 3 questions

You may take just Mechanics or just Electricity and Magnetism, or both. If you take both, you will receive a separate grade for each. Each section of each examination is 50 percent of the total grade; each question in a section has equal weight. Calculators are permitted on both sections of the exam. However, calculators cannot be shared with other students and calculators with typewriter-style (QWERTY) keyboards will not be permitted. On the following pages you will find the Table of Information that is provided to you during the exam.

If you are taking
— *Mechanics only*, please be careful to answer numbers 1–35;
— *Electricity and Magnetism only*, please be careful to answer numbers 36–70;
— *the entire examination* (Mechanics *and* Electricity and Magnetism), answer numbers 1–70 on your answer sheet.

GO ON TO THE NEXT PAGE.

ADVANCED PLACEMENT PHYSICS C TABLE OF INFORMATION

CONSTANTS AND CONVERSION FACTORS			
Proton mass,	$m_p = 1.67 \times 10^{-27}$ kg	Electron charge magnitude,	$e = 1.60 \times 10^{-19}$ C
Neutron mass,	$m_n = 1.67 \times 10^{-27}$ kg	1 electron volt,	1 eV = 1.60×10^{-19} J
Electron mass,	$m_e = 9.11 \times 10^{-31}$ kg	Speed of light,	$c = 3.00 \times 10^8$ m/s
Avogadro's number,	$N_A = 6.02 \times 10^{23}$ mol^{-1}	Universal gravitational constant,	$G = 6.67 \times 10^{-11}$ (N•m^2)/kg^2
Universal gas constant,	$R = 8.31$ J/(mol K)	Acceleration due to gravity at Earth's surface,	$g = 9.8$ m/s^2
Boltzmann's constant,	$k_B = 1.38 \times 10^{-23}$ J/K		

1 unified atomic mass unit,	1 u = 1.66×10^{-27} kg = 931 MeV/c^2
Planck's constant,	$h = 6.63 \times 10^{-34}$ J•s = 4.14×10^{-15} eV•s
	$hc = 1.99 \times 10^{-25}$ J•m = 1.24×10^3 eV•nm
Vacuum permittivity,	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N•m^2)
Coulomb's law constant,	$k = 1/(4\pi\varepsilon_0) = 9.0 \times 10^9$ (N•m^2)/C^2
Vacuum permeability,	$\mu_0 = 4\pi \times 10^{-7}$ (T•m)/A
Magnetic constant,	$k' = \mu_0/(4\pi) = 1 \times 10^{-7}$ (T•m)/A
1 atmosphere pressure,	1 atm = 1.0×10^5 N/m^2 = 1.0×10^5 Pa

UNIT SYMBOLS								
	meter,	m	mole,	mol	watt,	W	farad,	F
	kilogram,	kg	hertz,	Hz	coulomb,	C	tesla,	T
	second,	s	newton,	N	volt,	V	degree Celsius,	°C
	ampere,	A	pascal,	Pa	ohm,	Ω	electron volt,	eV
	kelvin,	K	joule,	J	henry,	H		

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

θ	0°	30°	37°	45°	53°	60°	90°
$\sin\theta$	0	1/2	3/5	$\sqrt{2}/2$	4/5	$\sqrt{3}/2$	1
$\cos\theta$	1	$\sqrt{3}/2$	4/5	$\sqrt{2}/2$	3/5	1/2	0
$\tan\theta$	0	$\sqrt{3}/3$	3/4	1	4/3	$\sqrt{3}$	∞

PREFIXES

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

The following assumptions are used in this exam.

I. The frame of reference of any problem is inertial unless otherwise stated.

II. The direction of current is the direction in which positive charges would drift.

III. The electric potential is zero at an infinite distance from an isolated point charge.

IV. All batteries and meters are ideal unless otherwise stated.

V. Edge effects for the electric field of a parallel plate capacitor are negligible unless otherwise stated.

MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$

$v_x^2 = v_{x0}{}^2 + 2a_x(x - x_0)$

$\vec{a} = \frac{\Sigma \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$\vec{F} = \frac{d\vec{p}}{dt}$

$\vec{J} = \int \vec{F}\,dt = \Delta\vec{p}$

$\vec{p} = m\vec{v}$

$\left|\vec{F}_f\right| \le \mu \left|\vec{F}_N\right|$

$\Delta E = W = \int \vec{F}\cdot d\vec{r}$

$K = \frac{1}{2}mv^2$

$P = \frac{dE}{dt}$

$P = \vec{F}\cdot\vec{v}$

$\Delta U_g = mg\Delta h$

$a_c = \frac{v^2}{r} = \omega^2 r$

$\vec{\tau} = \vec{r}\times\vec{F}$

$\vec{\alpha} = \frac{\Sigma\vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$I = \int r^2 dm = \Sigma mr^2$

$x_{cm} = \frac{\Sigma m_i x_i}{\Sigma m_i}$

$v = r\omega$

$\vec{L} = \vec{r}\times\vec{p} = I\vec{\omega}$

$K = \frac{1}{2}I\omega^2$

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

a = acceleration
E = energy
F = force
f = frequency
h = height
I = rotational inertia
J = impulse
K = kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
P = power
p = momentum
r = radius or distance
T = period
t = time
U = potential energy
v = velocity or speed
W = work done on a system
x = position
μ = coefficient of friction
θ = angle
τ = torque
ω = angular speed
α = angular acceleration
ϕ = phase angle

$\vec{F}_S = -k\Delta\vec{x}$

$U_S = \frac{1}{2}k(\Delta x)^2$

$x = x_{max}\cos(\omega t + \phi)$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_S = 2\pi\sqrt{\frac{m}{k}}$

$T_P = 2\pi\sqrt{\frac{\ell}{g}}$

$\left|\vec{F}_G\right| = \frac{Gm_1m_2}{r^2}$

$U_G = -\frac{Gm_1m_2}{r}$

ELECTRICITY AND MAGNETISM

$\left|\vec{F}_E\right| = \frac{1}{4\pi\varepsilon_0}\left|\frac{q_1q_2}{r^2}\right|$

$\vec{E} = \frac{\vec{F}_E}{q}$

$\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\varepsilon_0}$

$E_x = -\frac{dV}{dx}$

$\Delta V = -\int \vec{E}\cdot\vec{dr}$

$V = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q_i}{r_i}$

$U_E = qV = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$

$\Delta V = \frac{Q}{C}$

$C = \frac{\kappa\varepsilon_0 A}{d}$

$C_p = \sum_i C_i$

$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$

$I = \frac{dQ}{dt}$

$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2$

$R = \frac{\rho\ell}{A}$

$\vec{E} = \rho\vec{J}$

$I = Nev_d A$

$I = \frac{\Delta V}{R}$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$P = I\Delta V$

A = area
B = magnetic field
C = capacitance
d = distance
E = electric field
ε = emf
F = force
I = current
J = current density
L = inductance
ℓ = length
n = number of loops of wire per unit length
N = number of charge carriers per unit volume
P = power
Q = charge
q = point charge
R = resistance
r = radius or distance
t = time
U = potential or stored energy
V = electric potential
v = velocity or speed
ρ = resistivity
Φ = flux
κ = dielectric constant

$\vec{F}_M = q\vec{v}\times\vec{B}$

$\oint \vec{B}\cdot d\vec{\ell} = \mu_0 I$

$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{\ell}\times\vec{r}}{r^2}$

$\vec{F} = \int Id\vec{\ell}\times\vec{B}$

$B_S = \mu_0 nI$

$\Phi_B = \int \vec{B}\cdot d\vec{A}$

$\varepsilon = \oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$

$\varepsilon = -L\frac{dI}{dt}$

$U_L = \frac{1}{2}LI^2$

GO ON TO THE NEXT PAGE.

GEOMETRY AND TRIGONOMETRY

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$

$C = 2\pi r$

$s = r\theta$

Rectangular Solid

$V = \ell w h$

Cylinder

$V = \pi r^2 \ell$

$S = 2\pi r \ell + 2\pi r^2$

Sphere

$V = \frac{4}{3}\pi r^3$

$S = 4\pi r^2$

Right Triangle

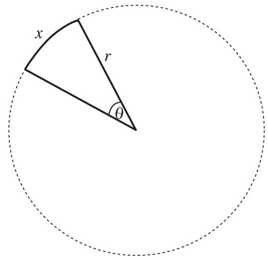
$a^2 + b^2 = c^2$

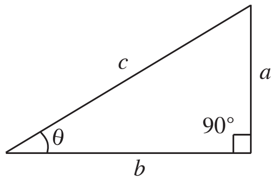
$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius
s = arc length
θ = angle





CALCULUS

$$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$$

$$\frac{d}{dx}(x^n) = nx^{n-1}$$

$$\frac{d}{dx}(e^{ax}) = ae^{ax}$$

$$\frac{d}{dx}(\ln ax) = \frac{1}{x}$$

$$\frac{d}{dx}[\sin(ax)] = a\cos(ax)$$

$$\frac{d}{dx}[\cos(ax)] = -a\sin(ax)$$

$$\int x^n\,dx = \frac{1}{n+1}x^{n+1},\ n \neq -1$$

$$\int e^{ax}\,dx = \frac{1}{a}e^{ax}$$

$$\int \frac{dx}{x+a} = \ln\left|x+a\right|$$

$$\int \cos(ax)\,dx = \frac{1}{a}\sin(ax)$$

$$\int \sin(ax)\,dx = -\frac{1}{a}\cos(ax)$$

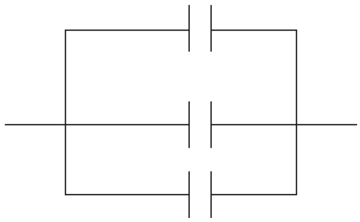
VECTOR PRODUCTS

$$\vec{A}\cdot\vec{B} = AB\cos\theta$$

$$\left|\vec{A}\times\vec{B}\right| = AB\sin\theta$$

PHYSICS C: ELECTRICITY AND MAGNETISM
SECTION I
Time—45 minutes
35 Questions

Directions: Each of the following questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then mark it on your answer sheet.

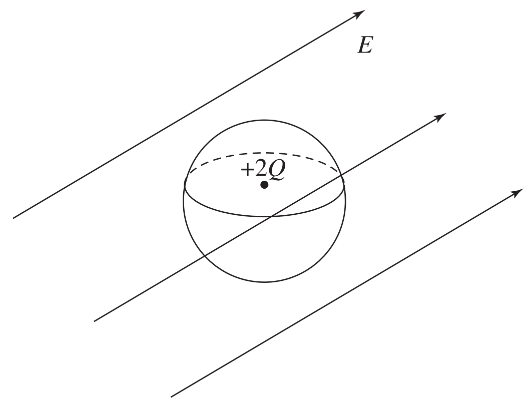


36. Three 3 μF capacitors are connected in parallel as shown above. Determine the equivalent capacitance of the arrangement.

(A) $\frac{1}{3}$ μF
(B) 1 μF
(C) 3 μF
(D) 6 μF
(E) 9 μF

37. A particular microwave requires some power, P, to operate. In America, a typical outlet provides electricity at 120 V. This would send a current, I, to the microwave. If this same microwave were taken to Europe, where the outlets provide twice the voltage, what would be the new current?

(A) $\frac{1}{4}I$
(B) $\frac{1}{2}I$
(C) I
(D) $2I$
(E) $4I$



38. A uniform electric field exists in a region, and then a neutral, conducting, spherical shell with a stationary charge $+2Q$ at its center is placed in the region, as shown above. The radius of the sphere is R. The flux through the sphere depends on the value of

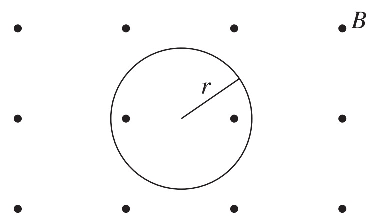
(A) E, Q, and R
(B) Only R
(C) E and Q
(D) R and Q
(E) Only Q

39. In a certain region, the electric field varies with the radius away from origin by the equation $E_r = -6r^2 + 4r + 3$, where r is given in meters and E in N/C. The potential difference between the origin and the point (3, 4) is

(A) –165 V
(B) –120 V
(C) 64 V
(D) 185 V
(E) 315 V

GO ON TO THE NEXT PAGE.

Questions 40-41



A particle of charge $-q$ and mass m moves with speed v perpendicular to a uniform magnetic field B directed out of the page. The path of the particle is a circle of radius r, as shown above.

40. Which of the following correctly gives the direction of motion and the magnitude of the acceleration of the charge?

	Direction	Acceleration of Charge
(A)	Clockwise	qBv
(B)	Clockwise	$\frac{qBv}{m}$
(C)	Counterclockwise	$\frac{qBv}{m}$
(D)	Counterclockwise	qBv
(E)	Counterclockwise	$\frac{qBv}{r}$

41. The frequency with which the particle completes the circular path is

(A) $\frac{v}{2r}$

(B) $\frac{mv}{2\pi r}$

(C) $\frac{2\pi r}{v}$

(D) $\frac{v}{2\pi r}$

(E) $\frac{v}{2\pi}$

42. A 30 μF capacitor has 6 millicoulombs of charge on each plate. The energy stored in the capacitor is most nearly

(A) 5.4×10^{-10} J
(B) 9.0×10^{-8} J
(C) 0.6 J
(D) 12.5 J
(E) 100 J

43. Two large, parallel conducting plates have a potential difference of V maintained across them. A proton starts at rest on the surface of one plate and accelerates toward the other plate. Its acceleration in the region between the plates is proportional to

(A) $\frac{1}{V}$

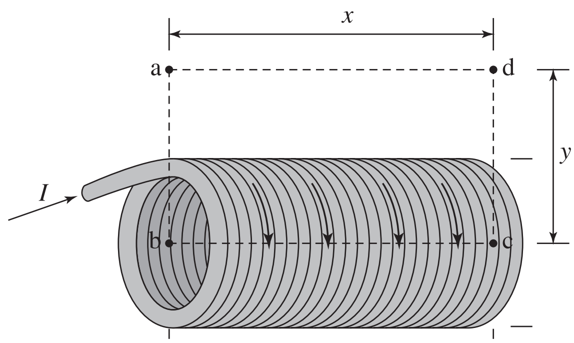
(B) $\frac{1}{\sqrt{V}}$

(C) $\sqrt{V}$

(D) V

(E) V^2

GO ON TO THE NEXT PAGE.



44. An ideal solenoid with N total turns has a current I passing through the helical wires that make up the solenoid. Ampere's law is used with a rectangular path *abcd* as shown above, to calculate the magnitude of the magnetic field B within the solenoid. The horizontal distances of the path are length x and the vertical distances of the path are length y. Which of the following equations results from the correct application of Ampere's law in this situation?

(A) $B(2x + 2y) = \mu_o NI$

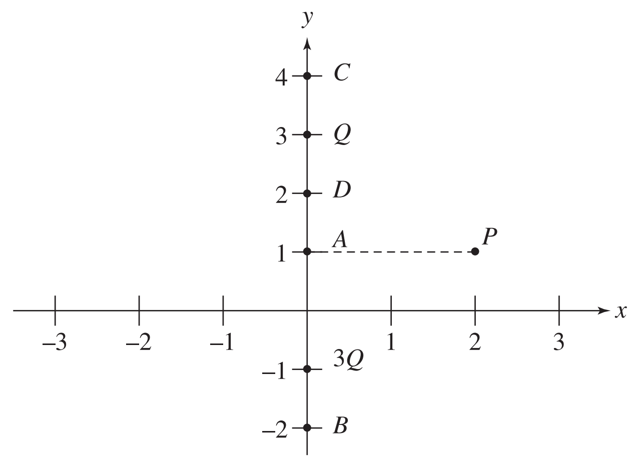
(B) $B(2x) = \mu_o NI$

(C) $B(x + 2y) = \mu_o NI$

(D) $B(2y) = \mu_o NI$

(E) $B(x) = \mu_o NI$

Questions 45-46



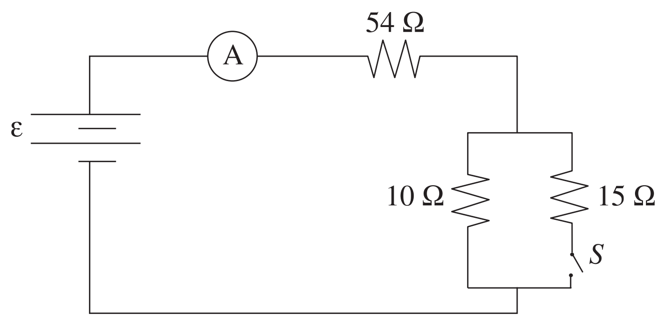
Particles of charge $+3Q$ and $+Q$ are located on the y-axis as shown above. Assume the particles are isolated from other particles and are stationary. *A, B, C, D,* and P are points in the plane as indicated in the diagram.

45. Which of the following describes the direction of the electric field at point P?

(A) $+x$ direction
(B) $-y$ direction
(C) components in both the $+x$ and $-y$ direction
(D) components in both $-x$ and $+y$ direction
(E) components in both $+x$ and $+y$ direction

46. At which of the labeled points is the electric potential zero?

(A) *A*
(B) *B*
(C) *C*
(D) *D*
(E) None of the points



47. When the switch S is *closed* in the circuit shown above the reading on the ammeter is 3 A. When the switch is *opened* the current through the 10 Ω resistor will

(A) double
(B) increase but not double
(C) remain the same
(D) decrease but not be halved
(E) be halved

48. Two conducting cylindrical wires are made out of the same material. Wire X has twice the length and half the radius as wire Y. What is the ratio $\frac{R_X}{R_Y}$ of their resistances?

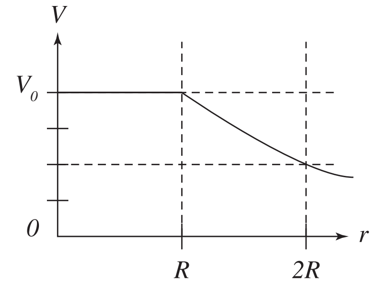
(A) 8

(B) 4

(C) 1

(D) $\frac{1}{2}$

(E) $\frac{1}{4}$



49. A graph of electric potential V as a function of the radius from the origin r is shown above. What can be concluded about the electric field in the region $0 < r < R$?

(A) It increases linearly as r increases.
(B) It decreases linearly as r increases.
(C) It is zero.
(D) It increases non-linearly as r increases.
(E) It decreases non-linearly as r increases.

50. Two parallel wires, each carrying a current I, attract each other with a force F. If both currents are halved the attractive force is

(A) $4F$

(B) $\frac{1}{\sqrt{2}}F$

(C) $\frac{1}{2}F$

(D) $\sqrt{2}F$

(E) $\frac{1}{4}F$

GO ON TO THE NEXT PAGE.

51. A square conducting loop of wire lies so that the plane of the loop is perpendicular to a constant magnetic field of strength B. Suppose the length of each side of the loop ℓ could be increased with time t so that $\ell = kt^2$, where k is a positive constant. What is the magnitude of the emf induced in the loop as a function of time?

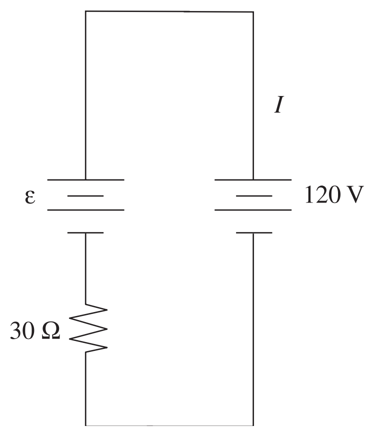
(A) $4Bk^2t^3$

(B) $2Bk^2t$

(C) $4Bkt^3$

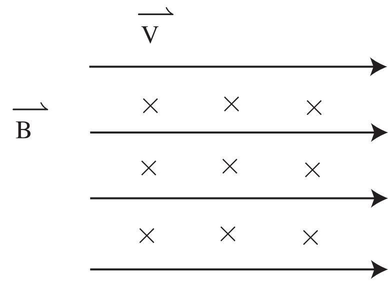
(D) $2Bkt$

(E) $\dfrac{Bk^2t^5}{5}$

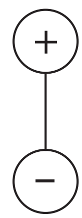


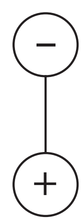
52. A battery with emf ε and internal resistance of 30 Ω is being recharged by connecting it to an outlet with a potential difference of 120 V as shown above. While it is being recharged, 3 A flows through the battery. Determine the emf of the battery.

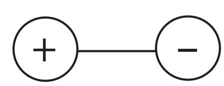
(A) 210 V
(B) 150 V
(C) 90 V
(D) 30 V
(E) 9 V



53. A dipole molecule is traveling into the plane of the page through a uniform magnetic field directed to the right. Which of the following arrangements of the dipole would result in 0 net force, but a non-zero net torque?

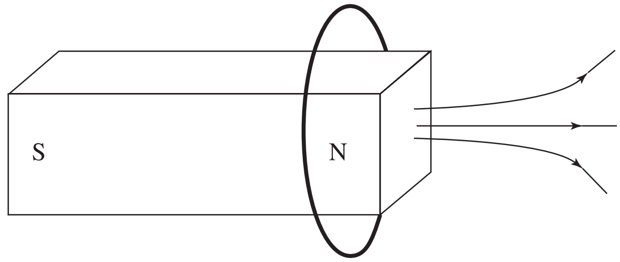
(A)


(B)


(C)


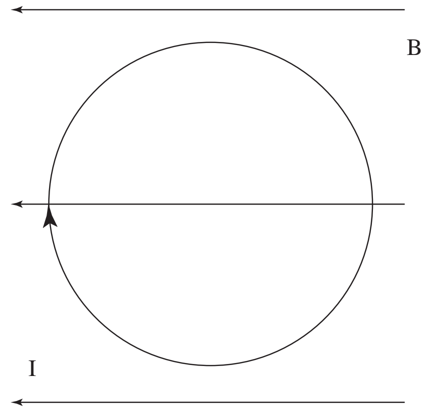
(D) All of the above
(E) None of the above

GO ON TO THE NEXT PAGE.



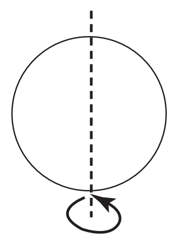
54. A conducting loop of wire is initially around a magnet as shown above. The magnet is moved to the left. What is the direction of the force on the loop and the direction of the magnetic field at the center of the loop due to the induced current?

	Direction of Force on Loop	Direction of Magnetic Field at Center of Loop Due to Induced Current
(A)	To the right	To the right
(B)	To the right	To the left
(C)	To the left	To the right
(D)	To the left	To the left
(E)	No direction; the force is zero	To the left

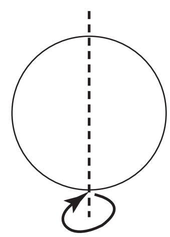


55. A loop of wire carrying a current *I* is initially in the plane of the page and is located in a uniform magnetic field *B*, which points toward the left side of the page, as shown above. Which of the following shows the correct initial rotation of the loop due to the force exerted by the magnetic field?

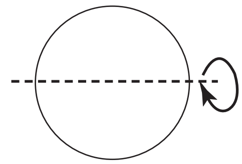
(A)



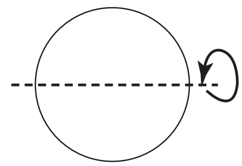
(B)



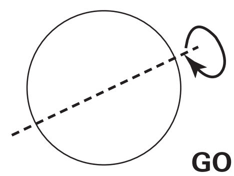
(C)



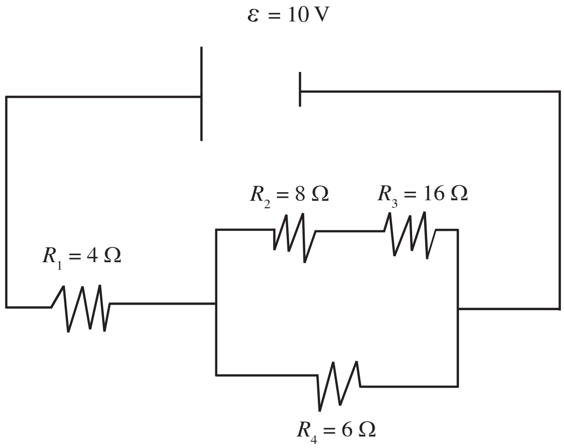
(D)



(E)



GO ON TO THE NEXT PAGE.



56. In the circuit above, what would be the initial current?

(A) $\frac{44}{5}$ A

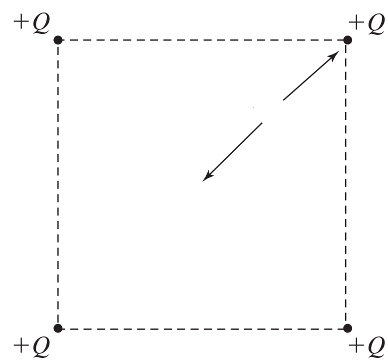
(B) $\frac{215}{62}$ A

(C) $\frac{25}{22}$ A

(D) $\frac{62}{215}$ A

(E) $\frac{5}{44}$ A

Questions 57-58



Four particles, each with a charge $+Q$, are held fixed at the corners of a square, as shown above. The distance from each charge to the center of the square is ℓ.

57. What is the magnitude of the electric field at the center of the square?

(A) 0

(B) $\frac{4kQ}{\ell^2}$

(C) $\frac{2kQ}{\ell^2}$

(D) $\frac{4kQ}{\sqrt{2}\ell^2}$

(E) $\frac{kQ}{\sqrt{2}\ell^2}$

58. What is the magnitude of the work required to move a charge of $+3Q$ from the center of the square to very far away?

(A) $\frac{12kQ^2}{\ell}$

(B) $\frac{12kQ^2}{\ell^2}$

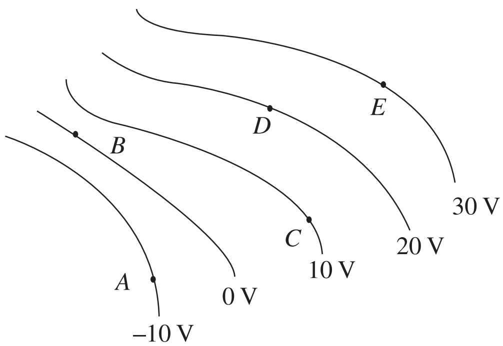
(C) $\frac{4kQ^2}{\ell^2}$

(D) $\frac{3kQ^2}{\ell}$

(E) $\frac{4kQ}{\ell}$

GO ON TO THE NEXT PAGE.

Questions 59-61



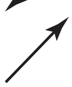
The diagram above shows equipotential lines produced by a charge distribution. *A, B, C, D,* and *E* are points in the plane.

59. At which point is the magnitude of the electric field the greatest?

(A) *A*
(B) *B*
(C) *C*
(D) *D*
(E) *E*

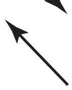
60. Which vector below bests describes the direction of the electric field at point *D* ?

(A) 

(B) 

(C) 

(D) 

(E) 

61. A particle with a –3 μC charge is released from rest on the –10 V equipotential line. What is the particle's change in electric potential energy when it reaches the 20 V equipotential line?

(A) 90 μJ
(B) 60 μJ
(C) 30 μJ
(D) –60 μJ
(E) –90 μJ

62. Which of Maxwell's equations allows for the calculation of a magnetic field due to a changing electric field?

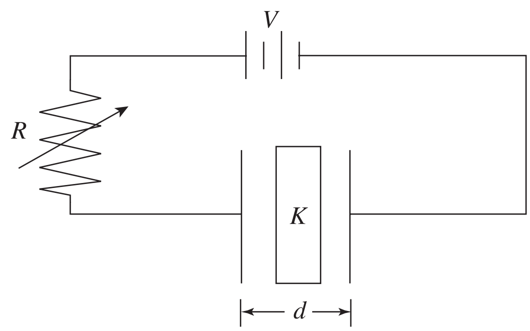
(A) $\oint E \bullet dA = \frac{q}{\varepsilon_0}$

(B) $\oint E \bullet d\ell = \frac{d\phi_B}{dt}$

(C) $\oint B \bullet dA = 0$

(D) $\oint B \bullet d\ell = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$

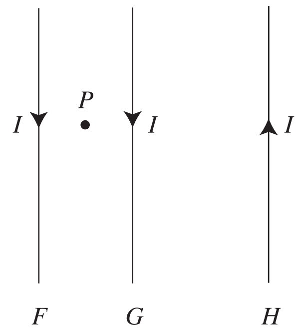
(E) None of the above



63. A parallel plate capacitor has a dielectric material between the plates with a constant *K*. The capacitor is connected to a variable resistor *R* and a power supply of potential difference *V*. Each plate of the capacitor has a cross-sectional area *A* and the plates are separated by a distance *d*. Which of the following changes could increase the capacitance and decrease the amount of charge stored on the capacitor?

(A) Increase *R* and increase *A*
(B) Decrease *V* and decrease *d*
(C) Decrease *R* and increase *d*
(D) Increase *K* and increase *V*
(E) Increase *K* and increase *R*

GO ON TO THE NEXT PAGE.



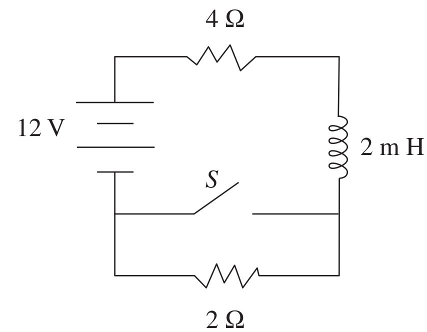
64. Three parallel wires, *F*, *G*, and *H*, all carry equal current *I*, in the directions shown above. Wire *G* is closer to wire *F* than to wire *H*. The magnetic field at point *P* is directed

(A) into the page
(B) out of the page
(C) to the left
(D) to the right
(E) toward the top of the page

65. A solid, metal object is isolated from other charges and has charge distributed on its surface. The charge distribution is not uniform. It may be correctly concluded that the

(A) electric field outside the object is zero
(B) the electric field outside the object is equal to the electric field inside the object
(C) the electric field outside the object is directly proportional to the distance away from the center of mass of the object
(D) the electric field outside the object, but very close to the surface, is equal to the surface charge density at any location divided by the permittivity of free space
(E) the electric potential on the surface of the object is not constant

<u>Questions 66-67</u> relate to the circuit represented below. The switch *S,* after being open a long time, is then closed.



66. What is the potential difference across the inductor immediately after the switch is closed?

(A) 0 V
(B) 2 V
(C) 4 V
(D) 8 V
(E) 12 V

67. What is the current through the 4 Ω resistor after the switch has been closed a long time?

(A) 2 A
(B) 1.2 A
(C) 6 A
(D) 3 A
(E) 1.5 A

---

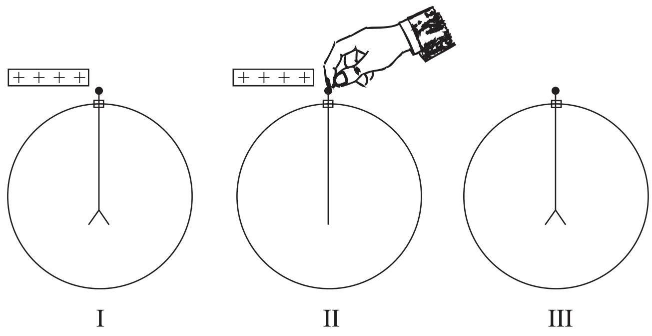
68. A spherical charge distribution varies with the radius *r* by the equation

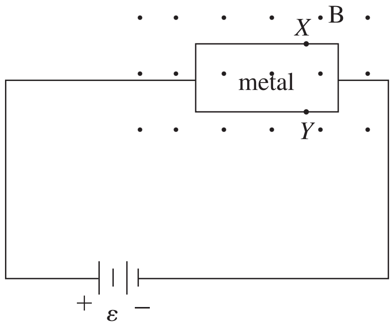
$\rho = ar$, where ρ is the volume charge density and *a* is a positive constant. The distribution goes out to a radius *R*.

Which of the following is true of the electric field strength due to this charge distribution at a distance *r* from the center?

(A) It increases as *r* approaches infinity.
(B) It decreases linearly for $r > R$.
(C) It increases linearly for $r > R$.
(D) It increases linearly for $r < R$.
(E) It increases non-linearly for $r < R$.

GO ON TO THE NEXT PAGE.





69. When a positively charged rod is brought near, but does not touch, the initially neutral electroscope shown above, the leaves repel (I). When the electroscope is then touched with a finger, the leaves hang vertically (II). Next when the finger and finally the rod are removed, the leaves repel again (III). During the process shown in Figure II

(A) electrons are going from the electroscope into the finger
(B) electrons are going from the finger into the electroscope
(C) protons are going from the rod into the finger
(D) protons are going from the finger into the rod
(E) electrons are going from the finger into the rod

70. A piece of metal in the plane of the page is connected in a circuit as shown above, causing electrons to move through the metal to the left. The piece of metal is in a magnetic field *B* directed out of the page. *X* and *Y* are points on the edge of the metal. Which of the following statements is true?

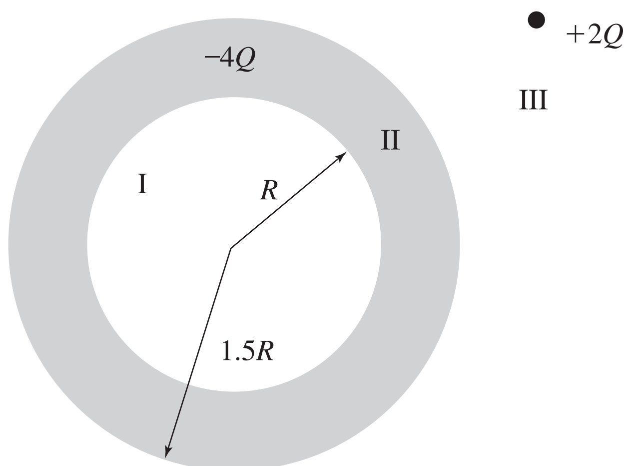
(A) The current will decrease to zero due to the magnetic field.
(B) The potentials at *X* and *Y* are equal.
(C) *X* is at a higher potential than *Y*.
(D) *Y* is at a higher potential than *X*.
(E) The current will increase exponentially due to the magnetic field.

STOP

END OF SECTION I, ELECTRICITY AND MAGNETISM

PHYSICS C: ELECTRICITY AND MAGNETISM
SECTION II
Time—45 minutes
3 Questions

Directions: Answer all three questions. The suggested time is about 15 minutes per question for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight.

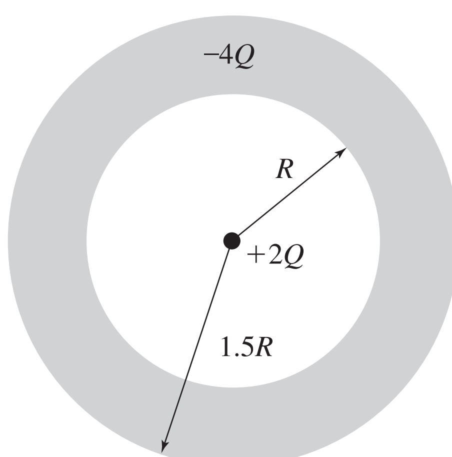


1. A spherical, metal shell of inner radius R and outer radius $1.5R$ has a charge of $-4Q$. A point charge of $+2Q$ is initially located outside the shell as shown above. Express all answers in terms of fundamental constants and given values.

   (a)

   i. Determine the charge on each surface of the spherical shell.

   ii. Sketch the electric field in regions I, II, and III.



Now the $+2Q$ point charge is moved to the center of the spherical shell as shown above.

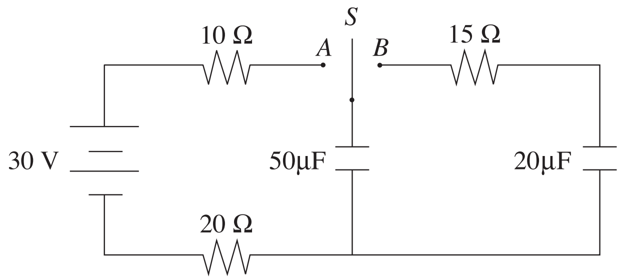
(b) Determine the electric field strength for the following radii.

i. $r < R$

ii. $R < r < 1.5R$

iii. $r > 1.5R$

(c) Determine the potential difference between infinity and the outside surface of the spherical shell.



2. In the circuit shown above, the switch S is initially in the open position and both capacitors are initially uncharged. Then the switch is moved to position A.

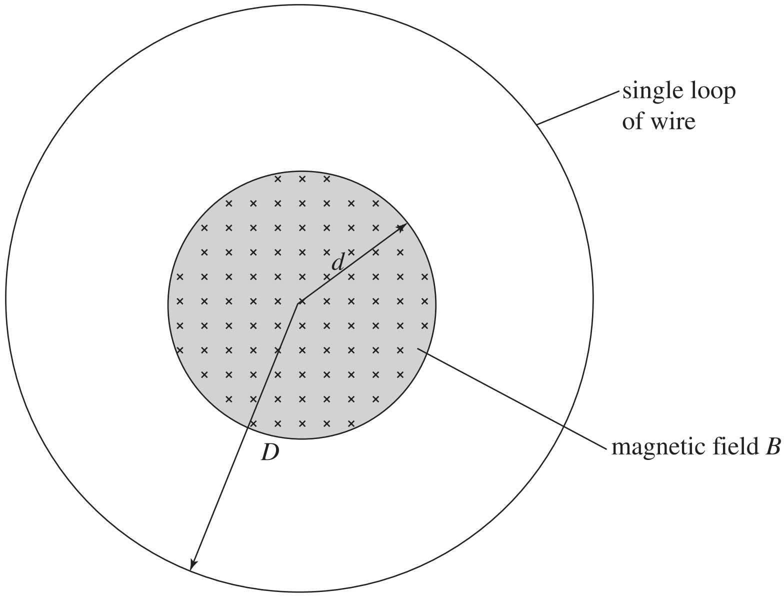
(a) Determine the current through the 20 Ω resistor immediately after the switch is moved to position A.

(b) Sketch a graph of voltage vs. time for the voltage across the 10 Ω resistor.

After a long time the switch is moved to position B.

(c) Determine the current through the 15 Ω resistor immediately after the switch is moved to position B.

(d) Determine the amount of charge stored on the upper plate of the 20 μF capacitor after a long time.



3. A uniform magnetic field B is directed into the page, and exists in a circular region of radius d. A single loop of wire of radius D is placed concentrically around the magnetic field region in the plane of the page. The initial magnetic field strength is B_0. Calculate the following in terms of given values and fundamental constants.

   (a) Determine the initial flux through the loop of wire.

   At time $t = 0$ s, the magnetic field strength as a function of time t is given by the equation $B(t) = B_0t^2$, where B_0 is a positive constant.

   (b) Determine the magnitude of the induced emf in the single loop.
   (c) Determine the direction of the induced current in the loop.

   The loop of wire has a resistance R.

   (d) Determine the energy dissipated in the loop up until a given time t_1.

STOP

END OF EXAM

Completely darken bubbles with a No. 2 pencil. If you make a mistake, be sure to erase mark completely. Erase all stray marks.

1.

YOUR NAME: ____
(Print) Last First M.I.

SIGNATURE: ______________________________ DATE: ____/____/____

HOME ADDRESS: ____
(Print) Number and Street

____
City State Zip Code

PHONE NO.: ____

IMPORTANT: Please fill in these boxes exactly as shown on the back cover of your test book.

2. TEST FORM

____

3. TEST CODE

0	A	J	0	0
1	B	K	1	1
2	C	L	2	2
3	D	M	3	3
4	E	N	4	4
5	F	O	5	5
6	G	P	6	6
7	H	Q	7	7
8	I	R	8	8
9			9	9

4. REGISTRATION NUMBER

0	0	0	0	0	0
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9

5. YOUR NAME

First 4 letters of last name					FIRST INIT	MID INIT
A	A	A	A		A	A
B	B	B	B		B	B
C	C	C	C		C	C
D	D	D	D		D	D
E	E	E	E		E	E
F	F	F	F		F	F
G	G	G	G		G	G
H	H	H	H		H	H
I	I	I	I		I	I
J	J	J	J		J	J
K	K	K	K		K	K
L	L	L	L		L	L
M	M	M	M		M	M
N	N	N	N		N	N
O	O	O	O		O	O
P	P	P	P		P	P
Q	Q	Q	Q		Q	Q
R	R	R	R		R	R
S	S	S	S		S	S
T	T	T	T		T	T
U	U	U	U		U	U
V	V	V	V		V	V
W	W	W	W		W	W
X	X	X	X		X	X
Y	Y	Y	Y		Y	Y
Z	Z	Z	Z		Z	Z

6. DATE OF BIRTH

Month	Day		Year	
JAN				
FEB	0	0	0	0
MAR	1	1	1	1
APR	2	2	2	2
MAY	3	3	3	3
JUN		4	4	4
JUL		5	5	5
AUG		6	6	6
SEP		7	7	7
OCT		8	8	8
NOV		9	9	9
DEC				

7. GENDER

MALE

FEMALE

1. A B C D E
2. A B C D E
3. A B C D E
4. A B C D E
5. A B C D E
6. A B C D E
7. A B C D E
8. A B C D E
9. A B C D E
10. A B C D E
11. A B C D E
12. A B C D E
13. A B C D E
14. A B C D E
15. A B C D E
16. A B C D E
17. A B C D E
18. A B C D E
19. A B C D E
20. A B C D E
21. A B C D E
22. A B C D E
23. A B C D E
24. A B C D E
25. A B C D E
26. A B C D E
27. A B C D E
28. A B C D E
29. A B C D E
30. A B C D E
31. A B C D E
32. A B C D E
33. A B C D E
34. A B C D E
35. A B C D E
36. A B C D E
37. A B C D E
38. A B C D E
39. A B C D E
40. A B C D E
41. A B C D E
42. A B C D E
43. A B C D E
44. A B C D E
45. A B C D E
46. A B C D E
47. A B C D E
48. A B C D E
49. A B C D E
50. A B C D E
51. A B C D E
52. A B C D E
53. A B C D E
54. A B C D E
55. A B C D E
56. A B C D E
57. A B C D E
58. A B C D E
59. A B C D E
60. A B C D E
61. A B C D E
62. A B C D E
63. A B C D E
64. A B C D E
65. A B C D E
66. A B C D E
67. A B C D E
68. A B C D E
69. A B C D E
70. A B C D E