Physics C AP Exam

Name: ________________ School: ________________ Score:

1.	11.	21.	31.
2.	12.	22.	32.
3.	13.	23.	33.
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1.

Physics C AP Exam

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2.
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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,	$1 \text{ eV} = 1.60 \times 10^{-19}$ 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,	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$	Universal gravitational constant,	$G = 6.67 \times 10^{-11}\ (\text{N}\cdot\text{m}^2)/\text{kg}^2$
Universal gas constant,	$R = 8.31$ J/(mol K)	Acceleration due to gravity at Earth's surface,	$g = 9.8\ \text{m/s}^2$
Boltzmann's constant,	$k_B = 1.38 \times 10^{-23}$ J/K		

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

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MECHANICS

$v_x = v_{x0} + a_x t$

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

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

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

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

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

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

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

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

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

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

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

$\Delta U_g = mg\Delta h$

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

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

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

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

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

$v = r\omega$

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

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

$\omega = \omega_0 + \alpha t$

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

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

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

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

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

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

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

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

$\left|\vec{F}_G\right| = \frac{Gm_1 m_2}{r^2}$

$U_G = -\frac{Gm_1 m_2}{r}$

ELECTRICITY & MAGNETISM

$\left|\vec{F}_E\right| = \frac{1}{4\pi\varepsilon_0}\left|\frac{q_1 q_2}{r^2}\right|$

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

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

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

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

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

$U_E = qV = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$

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

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

$C_p = \sum_i C_i$

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

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

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

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

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

$I = Nev_d A$

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

$R_s = \sum_i R_i$

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

$P = I\Delta V$

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

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

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

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

$\vec{F} = \int I\,d\vec{\ell} \times \vec{B}$

$B_s = \mu_0 n I$

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

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

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

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

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PHYSICS C: ELECTRICITY & MAGNETISM

SECTION I

Time—45 minutes

35 Questions

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

1. A nonconducting sphere is given a nonzero net electric charge, $+Q$, and then brought close to a neutral conducting sphere of the same radius. Which of the following will be true?
   (A) An electric field will be induced within the conducting sphere.
   (B) The conducting sphere will develop a net electric charge of $-Q$.
   (C) The spheres will experience an electrostatic attraction.
   (D) The spheres will experience an electrostatic repulsion.
   (E) The spheres will experience no electrostatic interaction.

2. If the total resistance of a circuit with fixed voltage, V, were doubled, the power dissipated by that same circuit would
   (A) increase by a factor of 4
   (B) increase by a factor of 2
   (C) decrease by a factor of 2
   (D) decrease by a factor of 4
   (E) Cannot be determined

3. Each of the following ionized isotopes is projected with the same speed into a uniform magnetic field **B** such that the isotope's initial velocity is perpendicular to **B**. Which combination of mass and charge would result in a circular path with the largest radius?
   (A) $m = 16$ u, $q = -5\ e$
   (B) $m = 17$ u, $q = -4\ e$
   (C) $m = 18$ u, $q = -3\ e$
   (D) $m = 19$ u, $q = -2\ e$
   (E) $m = 20$ u, $q = -1\ e$

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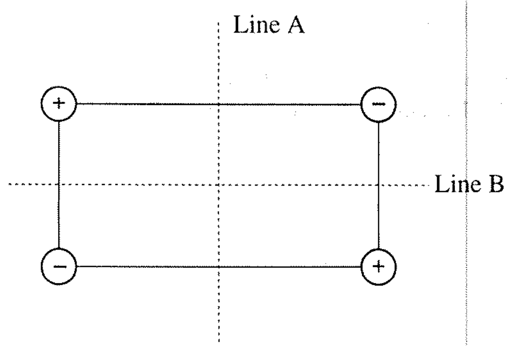
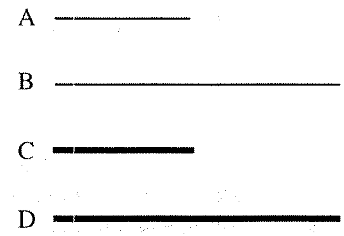


4. The picture above shows 4 charges fixed in position at the corners of a rectangle measuring 2 cm by 4 cm. Assuming the charges are all of equal magnitude, how many locations on either Line A or Line B would be places with 0 net electric field?

(A) 1
(B) 5
(C) All of Line A
(D) All of Line B
(E) All of both Line A and Line B

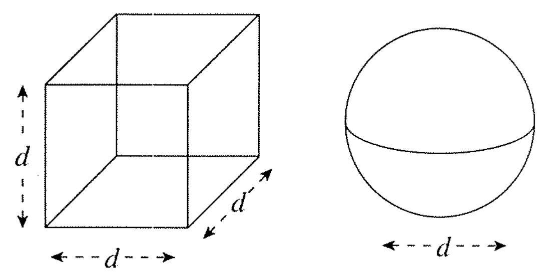


5. The four wires shown above are each made of aluminum. Which wire will have the greatest resistance?

(A) Wire A
(B) Wire B
(C) Wire C
(D) Wire D
(E) All the wires have the same resistance because they're all composed of the same material.

6. Which of the following is NOT equal to one tesla?

(A) 1 $J/(A \cdot m^2)$
(B) 1 $kg/(C \cdot s)$
(C) 1 $N/(A \cdot m)$
(D) 1 $V \cdot s/m^2$
(E) 1 $A \cdot N/V$



7. The figure above shows two Gaussian surfaces: a cube with side length d and a sphere with diameter d. The net electric charge enclosed within each surface is the same, $+Q$. If Φ_C denotes the total electric flux through the cubical surface, and Φ_S denotes the total electric flux through the spherical surface, then which of the following is true?

(A) $\Phi_C = (\pi/6)\Phi_S$
(B) $\Phi_C = (\pi/3)\Phi_S$
(C) $\Phi_C = \Phi_S$
(D) $\Phi_C = (3/\pi)\Phi_S$
(E) $\Phi_C = (6/\pi)\Phi_S$

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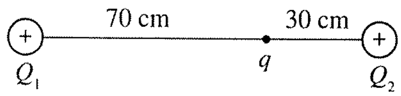
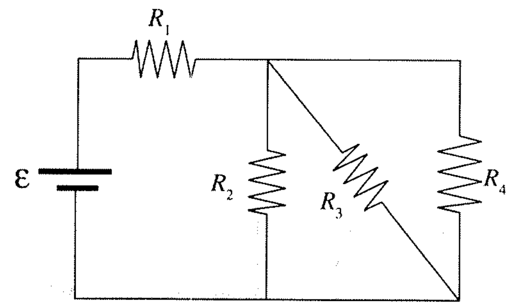


8. The picture above shows two positive charges, Q_1 and Q_2, of equal magnitude that are fixed in place. If a third positive charge, q, were released from rest at the position shown, at what position would it first return to rest? Assume ideal conditions and that Q_1 occupies the position of $x = 0$ cm and Q_2 occupies the position of $x = 1$ cm.
   - (A) $x = 30$ cm
   - (B) $x = 50$ cm
   - (C) $x = 70$ cm
   - (D) Cannot be determined without knowing the magnitude of q
   - (E) It never returns to rest.

9. An object carries a charge of –1 C. How many excess electrons does it contain?
   - (A) 6.25×10^{18}
   - (B) 8.00×10^{18}
   - (C) 1.60×10^{19}
   - (D) 3.20×10^{19}
   - (E) 6.25×10^{19}

Questions 10–11

Each of the resistors shown in the circuit below has a resistance of 200 Ω. The emf of the ideal battery is 24 V.



10. How much current is supported by the voltage source?
    - (A) 30 mA
    - (B) 48 mA
    - (C) 64 mA
    - (D) 72 mA
    - (E) 90 mA

11. What is the ratio of the power dissipated by R_1 to the power dissipated by R_4?
    - (A) 1/9
    - (B) 1/4
    - (C) 1
    - (D) 4
    - (E) 9

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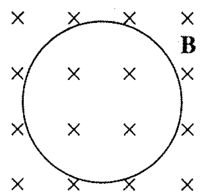
12. What is the value of the following product?

$$20\ \mu F \times 500\ \Omega$$

(A) 0.01 henry
(B) 0.01 ampere per coulomb
(C) 0.01 weber
(D) 0.01 second
(E) 0.01 volt per ampere

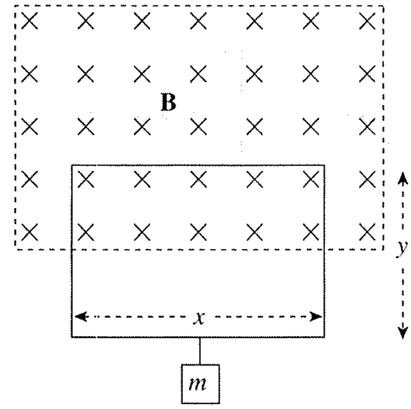


13. A copper wire in the shape of a circle of radius 1 m, lying in the plane of the page, is immersed in a magnetic field, **B**, that points into the plane of the page. The strength of **B** varies with time, t, according to the equation

$$B(t) = 2t(1 - t)$$

where B is given in teslas when t is measured in seconds. What is the magnitude of the induced electric field in the wire at time $t = 1$ s?

(A) $(1/\pi)$ N/C
(B) 1 N/C
(C) 2 N/C
(D) π N/C
(E) 2π N/C



14. In the figure above, the top half of a rectangular loop of wire, x meters by y meters, hangs vertically in a uniform magnetic field, **B**. Describe the magnitude and direction of the current in the loop necessary for the magnetic force to balance the weight of the mass m supported by the loop.

(A) $I = mg/xB$, clockwise

(B) $I = mg/xB$, counterclockwise

(C) $I = mg/\left(x + \frac{1}{2}y\right)B$, clockwise

(D) $I = mg/\left(x + \frac{1}{2}y\right)B$, counterclockwise

(E) $I = mg/(x + y)B$, clockwise

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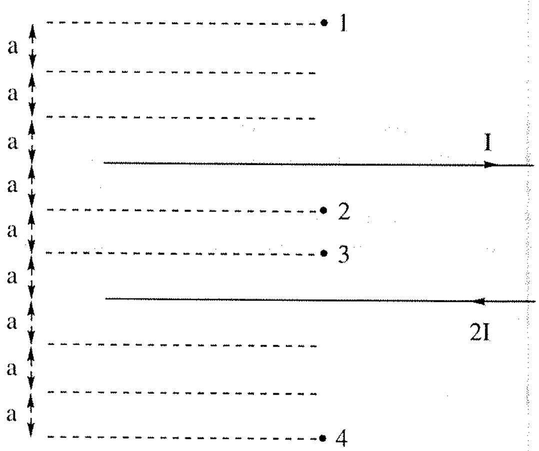
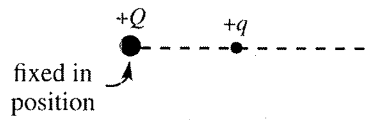
15. A particle with a charge of $q_1 = 10$ nC is held in place. A second particle of charge $q_2 = -5$ nC and mass $m = 5 \times 10^{-10}$ kg is released from rest 2 cm away from the first particle. How fast will it be moving when it is 1 cm away from the first particle?

(A) 100 m/s
(B) 200 m/s
(C) 300 m/s
(D) 400 m/s
(E) 500 m/s

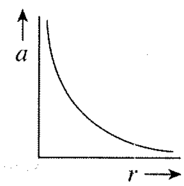


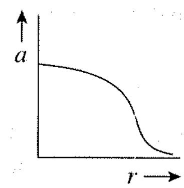
16. The figure above shows a pair of long, straight current-carrying wires and four marked points. At which of these points is the net magnetic field zero?

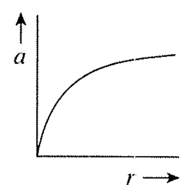
(A) Point 1 only
(B) Points 1 and 2 only
(C) Point 2 only
(D) Points 3 and 4 only
(E) Point 3 only

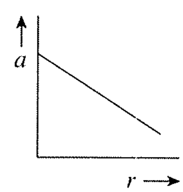


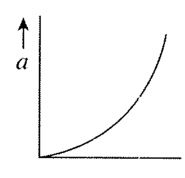
17. The figure above shows two positively charged particles. The $+Q$ charge is fixed in position, and the $+q$ charge is brought close to $+Q$ and released from rest. Which of the following graphs best depicts the acceleration of the $+q$ charge as a function of its distance r from $+Q$?

(A)


(B)


(C)


(D)


(E)


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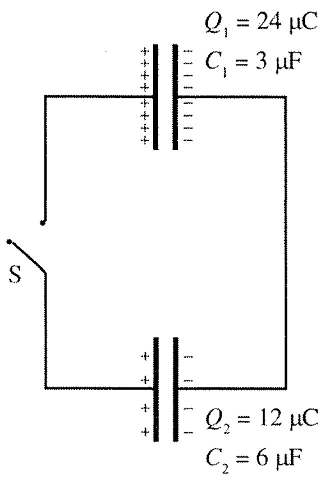
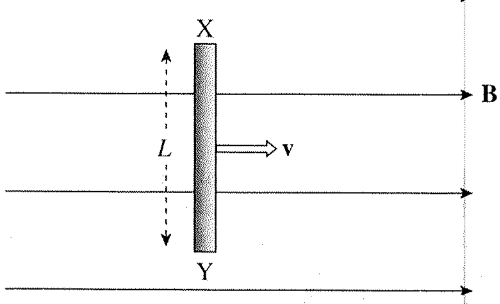


18. Once the switch S in the figure above is closed and electrostatic equilibrium is regained, how much charge will be stored on the positive plate of the 6 μF capacitor?

(A) 9 μC
(B) 18 μC
(C) 24 μC
(D) 27 μC
(E) 36 μC

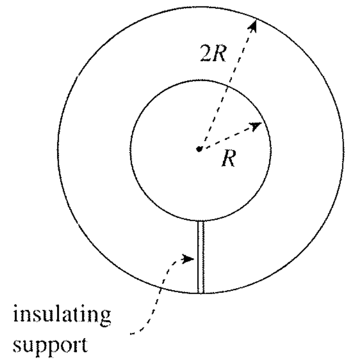


19. A metal bar of length L is pulled with velocity **v** through a uniform magnetic field, **B**, as shown above. What is the voltage produced between the ends of the bar?

(A) vB, with point X at a higher potential than point Y
(B) vB, with point Y at a higher potential than point X
(C) vBL, with point X at a higher potential than point Y
(D) vBL, with point Y at a higher potential than point X
(E) None of the above

20. An electric dipole consists of a pair of equal but opposite point charges of magnitude 4.0 nC separated by a distance of 2.0 cm. What is the electric field strength at the point midway between the charges?

(A) 0
(B) 9.0×10^4 V/m
(C) 1.8×10^5 V/m
(D) 3.6×10^5 V/m
(E) 7.2×10^5 V/m



21. The figure above shows a cross section of two concentric spherical metal shells of radii R and $2R$, respectively. Find the capacitance.

(A) $1/(8\pi\varepsilon_0 R)$
(B) $1/(4\pi\varepsilon_0 R)$
(C) $2\pi\varepsilon_0 R$
(D) $4\pi\varepsilon_0 R$
(E) $8\pi\varepsilon_0 R$

22. Traveling at an initial speed of 1.5×10^6 m/s, a proton enters a region of constant magnetic field, **B**, of magnitude 1.0 T. If the proton's initial velocity vector makes an angle of 30° with the direction of **B**, compute the proton's speed 4 s after entering the magnetic field.

(A) 5.0×10^5 m/s
(B) 7.5×10^5 m/s
(C) 1.5×10^6 m/s
(D) 3.0×10^6 m/s
(E) 6.0×10^6 m/s

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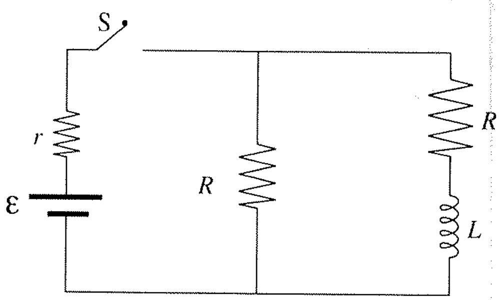
Questions 23–25

There is initially no current through any circuit element in the following diagram.



23. What is the current through r immediately after the switch S is closed?

(A) 0

(B) $\dfrac{\varepsilon}{r+R}$

(C) $\dfrac{\varepsilon}{r+2R}$

(D) $\dfrac{\varepsilon(r+R)}{rR}$

(E) $\dfrac{\varepsilon(2R)}{2Rr+2R}$

24. After the switch has been kept closed for a long time, how much energy is stored in the inductor?

(A) $\dfrac{L\varepsilon^2}{2(r+R)^2}$

(B) $\dfrac{L\varepsilon^2}{2(2r+R)^2}$

(C) $\dfrac{L\varepsilon^2}{4(2r+R)^2}$

(D) $\dfrac{L(\varepsilon R)^2}{8(2r+R)^2}$

(E) $\dfrac{L\varepsilon^2}{8(2r+R)^2}$

25. After having been closed for a long time, the switch is suddenly opened. What is the current through r immediately after S is opened?

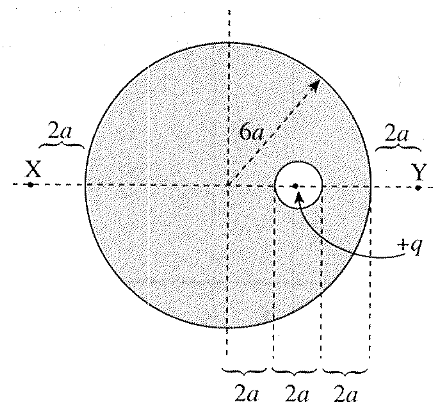
(A) 0

(B) $\dfrac{\varepsilon}{r+R}$

(C) $\dfrac{\varepsilon}{r+2R}$

(D) $\dfrac{\varepsilon(r+R)}{rR}$

(E) $\dfrac{\varepsilon(2R)}{r(2R)+2R}$



26. A solid, neutral metal sphere of radius $6a$ contains a small cavity, a spherical hole of radius a as shown above. Within this cavity is a charge, $+q$. If E_X and E_Y denote the strength of the electric field at points X and Y, respectively, which of the following is true?

(A) $E_Y = 4E_X$
(B) $E_Y = 16E_X$
(C) $E_Y = E_X$
(D) $E_Y = (11/5)E_X$
(E) $E_Y = (11/5)^2E_X$

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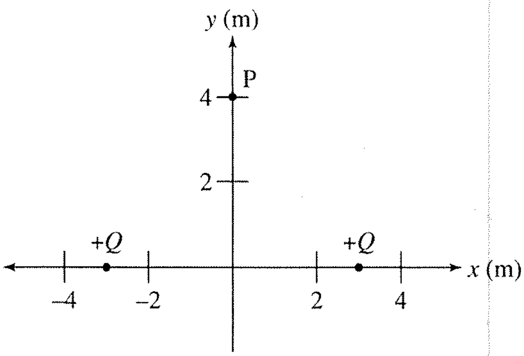


27. Two particles of charge $+Q$ are located on the x-axis, as shown above. Determine the work done by the electric field to move a particle of charge $-Q$ from very far away to point P.

(A) $\frac{2kQ}{5}$

(B) $\frac{2kQ^2}{5}$

(C) $-\frac{2kQ^2}{5}$

(D) $\frac{kQ^2}{5}$

(E) $-\frac{3kQ^2}{5}$

28. A battery is connected in a series with a switch, a resistor of resistance R, and an inductor of inductance L. Initially, there is no current in the circuit. Once the switch is closed and the circuit is completed, how long will it take for the current to reach 99% of its maximum value?

(A) $(\ln \frac{99}{100})RL$

(B) $(\ln 99)RL$

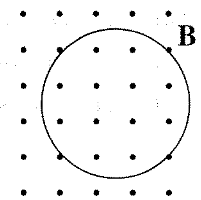
(C) $(\ln \frac{1}{100})\frac{L}{R}$

(D) $\frac{L}{R}(\ln \frac{100}{99})$

(E) $(\ln 100)\frac{L}{R}$

29. What is the maximum number of 40 W light bulbs that could be connected in parallel with a 120 V source? The total current cannot exceed 5 A or the circuit will blow a fuse.

(A) 3
(B) 6
(C) 9
(D) 12
(E) 15



30. The metal loop of wire shown above is situated in a magnetic field **B** pointing out of the plane of the page. If **B** decreases uniformly in strength, the induced electric current within the loop is

(A) clockwise and decreasing
(B) clockwise and increasing
(C) counterclockwise and decreasing
(D) counterclockwise and constant
(E) counterclockwise and increasing

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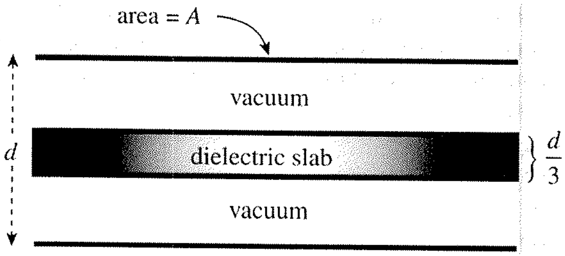


31. A dielectric of thickness $\frac{d}{3}$ is placed between the plates of a parallel-plate capacitor, as shown above. If K is the dielectric constant of the slab, what is the capacitance?

(A) $\dfrac{\varepsilon_0 A(2+3K)}{d}$

(B) $\dfrac{d}{\varepsilon_0 A(2+3K)}$

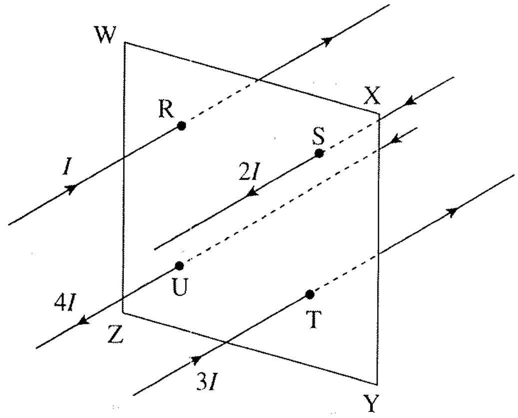
(C) $\dfrac{3\varepsilon_0 A}{d(2K+1)}$

(D) $\dfrac{3K\varepsilon_0 A}{d(2K+1)}$

(E) $\dfrac{3K\varepsilon_0 A}{d}$

32. Consider the two source charges shown above. At how many points in the plane of the page, in a region around these charges, are both the electric field and the electric potential equal to zero?

(A) 0
(B) 1
(C) 2
(D) 3
(E) 4



33. The figure above shows four current-carrying wires passing perpendicularly through the interior of a square whose vertices are W, X, Y, and Z. The points where the wires pierce the plane of the square (namely, R, S, T, and U) themselves form the vertices of a square each side of which has half the length of each side of WXYZ. If the currents are as labeled in the figure, what is the absolute value of

$$\oint \mathbf{B} \cdot d\ell$$

where the integral is taken around WXYZ?

(A) $\frac{1}{2}\mu_0 I$
(B) $\mu_0 I$
(C) $\sqrt{2}\,\mu_0 I$
(D) $2\mu_0 I$
(E) $5\mu_0 I$

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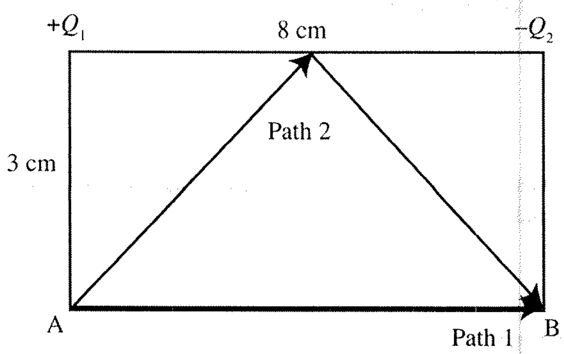


34. A particle with charge $+q$ is moved from point A to point B along Path 1 in the picture above and experiences a change in potential energy given by ΔU. What would the change in potential energy be if the charge had the opposite sign and moved along Path 2 from point A to point B instead of along Path 1?

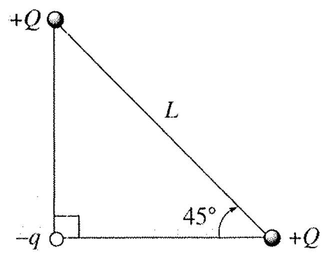
(A) $-\left(\frac{10}{8}\right)\Delta U$

(B) $-\Delta U$

(C) ΔU

(D) $\left(\frac{10}{8}\right)\Delta U$

(E) Cannot be determined without knowing the values of Q_1 and Q_2



35. Two point charges, each $+Q$, are fixed a distance L apart. A particle of charge $-q$ and mass m is placed as shown in the figure above. What is this particle's initial acceleration when released from rest?

(A) $\dfrac{\sqrt{2}Qq}{2\pi\varepsilon_0 L^2 m}$

(B) $\dfrac{\sqrt{2}Qq}{\pi\varepsilon_0 L^2 m}$

(C) $\dfrac{2Qq}{\pi\varepsilon_0 L^2 m}$

(D) $\dfrac{2\sqrt{2}Qq}{\pi\varepsilon_0 L^2 m}$

(E) $\dfrac{4Qq}{\pi\varepsilon_0 L^2 m}$

STOP

END OF SECTION I, ELECTRICITY & MAGNETISM

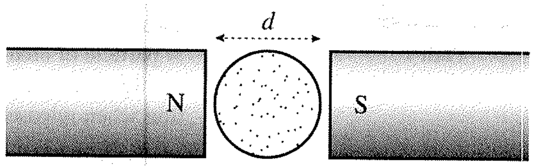
PHYSICS C: ELECTRICITY & MAGNETISM

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.



$\vec{v}$ into plane of the page

1. A stream of equal but oppositely charged particles is moving through a cylinder that is between two magnets as shown above. The magnets create a magnetic field **B** that points from the north pole to the south pole. The particles move with speed v, and the cylinder has a diameter d.
   (a) The magnetic field will cause the charged particles to move in a way that creates an electric field. Indicate this electric field's direction and qualitatively describe the magnitude of the resulting electric forces on the particles in relation to the magnetic forces the particles experience.
   (b) Assume enough time has passed that a constant potential difference V is established in the cylinder. What is the value of the particles' speed v in terms of the other known values?
   (c) Given that one of the positive particles has a mass of m, how much work is done on that particle by the magnetic force in 1 second?
   (d) An overall neutral particle is structured in such a way that it has a slight positive charge on its right side and a slight negative charge on its left side. If this particle were moved through the cylinder, describe the effect the magnetic field would have on such a particle. Ignore any electric forces for this question.

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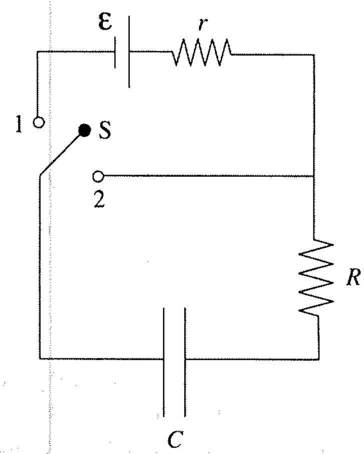
2. In the circuit shown below, the capacitor is initially uncharged and there is no current in any circuit element.



In each of the following, k is a number greater than 1; write each of your answers in terms of $\mathcal{E}$, r, R, C, k, and fundamental constants.

(a) At $t = 0$, the switch S is moved to position 1.

i. At what time t is the current through R equal to $\frac{1}{k}$ of its initial value?

ii. At what time t is the charge on the capacitor equal to $\frac{1}{k}$ of its maximum value?

iii. At what time t is the energy stored in the capacitor equal to $\frac{1}{k}$ of its maximum value?

(b) After the switch has been at position 1 for a very long time, it is then moved to position 2. Let this redefine $t = 0$ for purposes of the following questions.

i. How long will it take for the current through R to equal $\frac{1}{k}$ of its initial value?

ii. At what time t is the charge on the capacitor equal to $\frac{1}{k}$ of its initial value?

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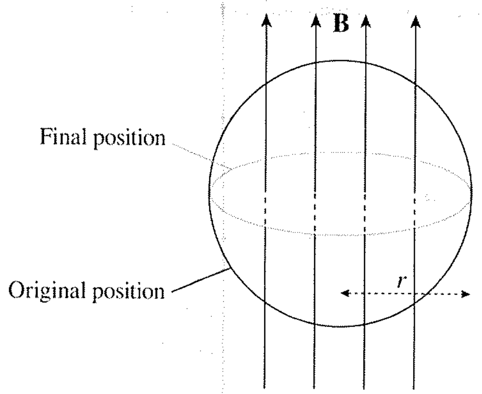

3. The metal ring of radius r shown above has a magnetic field of strength B passing through it as shown. The ring begins to rotate at a steady angular velocity and continues until it has rotated 90°. It completes the rotation in T seconds.

(a) Find the average induced emf. Express your answer in terms of B, r, T, and fundamental constants.

(b) During the rotation, what is the direction of the induced current in the ring?

(c) If the ring has a resistance of R Ω, what is the magnitude of the average induced current? Express your answer in terms of B, r, R, T, and fundamental constants.

(d) If the time at which the maximum instantaneous magnitude of induced emf occurs is given as t_{max}, what is the magnitude of that emf? Express your answer in terms of B, r, T, t_{max}, and fundamental constants.

(e) In terms of known values, what would be the value of t_{max} in (d)?

STOP

END OF EXAM

T1

1. C	11. E	21. E	31. D
2. C	12. D	22. C	32. A
3. E	13. B	23. B	33. D
4. A	14. A	24. B	34. B
5. B	15. C	25. A	35. A
6. E	16. A	26. C	
7. C	17. A	27. B	
8. A	18. C	28. E	
9. A	19. E	29. E	
10. E	20. E	30. D	