Solutions

Physics 161: Capacitance, Resistance, Magnetostatics

Practice for Exam 3

1. A capacitor consists of two metal spheres which are held separate from one another by an insulator. When a charge of 1 μC is removed from one of the spheres and place on the other sphere, the potential between them is 5 V. The capacitance is

(a) 0.2 μF

(b) 5 μF

(c) 5×10^6 F

(d) 2 F

$C = \frac{Q}{V} = \frac{1\,\mu C}{5\,V} = \frac{1}{5}\times10^{-6}\,F = 0.2\,\mu F$

2. A parallel plate capacitor consists of two metal plates, each having an area of 1 m^2. The plates are separated from one another by 1 cm. If the separation is increased to 2 cm, the capacitance

(a) Increases by a factor of 2

(b) Decreases by a factor of 2

(c) Increases by a factor of 4

(d) Decreases by 2 μF.

3. A parallel plate capacitor consists of two metal plates, each having an area of 1 m^2. The plates are separated from one another in a vacuum by 1 cm. If an insulator having dielectric constant of 3 is inserted between the plates, the capacitance

(a) Decreases by a factor of 3

(b) Increases by a factor of 3

(c) Decreases by a factor of 9

(d) Increases by a factor of 9

4. The units of capacitance are

(a) Volts/Coulomb

(b) Coulomb/Volt

(c) Volt-Coulomb

(d) Volts/meter

5. What is the capacitance of two concentric spherical metal shells, one having a radius a and the other having a radius b? The space between the shells is filled with an insulator having dielectric constant κ.

(a) $4\pi\kappa\epsilon_0\frac{ab}{b-a}$

(b) $2\pi\kappa\epsilon_0/\ln\left(\frac{b}{a}\right)$

(c) $4\pi\kappa\epsilon_0\frac{ab}{a+b}$

(d) $4\pi\kappa\epsilon_0 a$

6. What is the capacitance per unit length of two very long concentric cylinders, one having a radius a and the other having a radius b? The space between the cylinders is filled with an insulator having a dielectric constant κ.

(a) $4\pi\kappa\epsilon_0\frac{ab}{b-a}$

(b) $2\pi\kappa\epsilon_0/\ln\left(\frac{b}{a}\right)$
(c) $4\pi\kappa\epsilon_0\frac{ab}{a+b}$
(d) $4\pi\kappa\epsilon_0 a$

7. The electric susceptibility of an insulator is a measure of
(a) the polarization per applied electric field
(b) how easy it is for a material to break when dropped.
(c) the ease with which a voltage can be applied across it.
(d) its total charge.

8. How much work must be performed to charge a capacitor C to a voltage V?
(a) CV
(b) $\frac{1}{2}C^2/V$
(c) $\frac{1}{2}CV^2$
(d) $2VC^2$

9. What is the equivalent capacitance of two capacitors in series if one is 1 μF and the other is 3 μF?

$\left(\frac{1}{1}+\frac{1}{3}\right)^{-1} = \frac{3}{4}$

(a) 3 μF
(b) 4/3 μF
(c) 4 μF
(d) 3/4 μF

10. A voltage V is placed across two capacitors C_1 and C_2 in series. How is the voltage divided between the two?
(a) The largest voltage drop is across the largest capacitor.
(b) The largest voltage drop is across the smallest capacitor.
(c) Half the voltage is dropped across one capacitor and half the voltage is dropped across the other.
(d) The voltage across each capacitor is V.

11. A typical breakdown threshold for a plastic insulator is
(a) 5000 V
(b) 1×10^8 V/m
(c) 5×10^{-15} J
(d) 10^3 C

12. What is the permittivity of free space?
(a) 8.8×10^{-12} N m^2/C^2
(b) 8.8×10^{-12} C^2/(Nm^2)
(c) 8.8×10^{-12} N/(C^{2}m^2)
(d) 8.8×10^{-12} NC^2/m^2

13. If a wire having a cross sectional area of 1 cm^2 carries a current of 2 A, what is the average current density in the wire?
(a) 2 A/cm^2
(b) 0.5 A/cm
(c) 5 A/cm^3
(d) 1.414 A cm^3

14. A conduction electron in a metal is

(a) an electron which is able to move freely from one atom to the next
(b) an electron in one of the outer most shells of a metal atom
(c) an electron which contributes to the conductivity of the metal
(d) an electron which *leads the way for the other electrons*

15. What is Ohm's law?

(a) The current in a conductor is proportional to the voltage across the conductor.
(b) The current in a conductor decreases exponentially with time.
(c) The current in a conductor is proportional to the square of the voltage.
(d) The voltage across a battery is always slightly smaller than the ideal voltage.

16. What is resistivity?

(a) The tendency to resist.
(b) A small resistance
(c) The proportionality constant between the electric field and the current density.
(d) The act of resisting.

17. What is the resistance between two parallel metal plates of area A and plate separation d, the space between the plates filled with a poorly conducting substance having a resistivity ρ?

(a) $\rho A/d$
(b) $\rho d/A$
(c) ρAd
(d) $d/(\rho A)$

18. What is the resistance of two concentric spherical metal shells, one having a radius a and the other having a radius b? The space between the shells is filled with a poorly conducting substance having a resistivity ρ.

(a) $\frac{\rho}{4\pi}\left(\frac{b-a}{ba}\right)$
(b) $\frac{\rho}{2\pi\ell}\ln\left(\frac{b}{a}\right)$
(c) $4\pi\rho\frac{ab}{a+b}$
(d) $4\pi\rho a$

19. What is the resistance between two long concentric cylinders of length ℓ, one having a radius a and the other having a radius b? The space between the cylinders is filled with a poorly conducting substance having a resistivity ρ.

(a) $\frac{\rho}{4\pi}\left(\frac{b-a}{ba}\right)$
(b) $\frac{\rho}{2\pi\ell}\ln\left(\frac{b}{a}\right)$
(c) $4\pi\rho\frac{ab}{a+b}$
(d) $4\pi\rho a$

18. What is the typical resistivity of a metal?

(a) $10^{-8}\Omega m$
(b) $10^{-8}\Omega/\mathrm{m}$
(c) $10^{-8}\mathrm{m}/\Omega$
(d) $10^{-8}\Omega^{-1}\mathrm{m}^{-1}$

19. How does the resistivity of a metal typically change with temperature?

(a) It increases with increasing temperature
(b) It decreases with increasing temperature
(c) It doesn't change at all.
(d) *It increases exponentially* with decreasing *temperature.*

20. A current I passes through a battery having a voltage V. At what rate is work done by the battery?
(a) VI
(b) V/I
(c) I/V

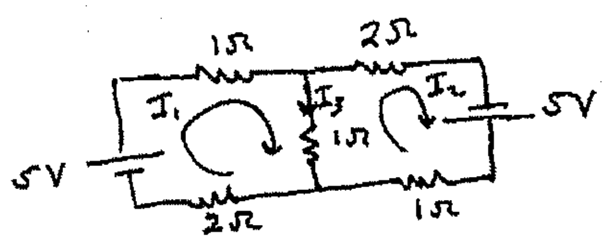
21. What is Kirchoff's voltage law?
(a) The sum of the voltages around a closed loop is zero.
(b) The sum of the voltages around a closed loop is equal to IR.
(c) The sum of the currents entering any node is zero.
(d) The sum of the voltages around a closed loop depends on the strength of the battery.

22. What is the equivalent resistance of two resistors R_1 and R_2 in series?
(a) $R_1 + R_2$
(b) $\frac{1}{R_1} + \frac{1}{R_2}$
(c) $\left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$
(d) $\frac{1}{R_1+R_2}$

23. How is the voltage divided across two resistors in series?
(a) The larger voltage is dropped across the larger resistor.
(b) The larger voltage is dropped across the smaller resistor.
(c) The same voltage is across both resistors.

24. How is the current I divided between two resistors R_1 and R_2 in parallel?
(a) $I_1 = \frac{R_2}{R_1+R_2} I$; $I_2 = \frac{R_1}{R_1+R_2} I$
(b) $I_1 = \frac{R_1}{R_1+R_2} I$; $I_2 = \frac{R_2}{R_1+R_2} I$

25. Find the current in each branch of the multiloop circuit shown below.



$5 - 3I_1 - (I_1 - I_2) = 0$
$5 - 3I_2 - (I_2 - I_1) = 0$
$-4I_1 + I_2 = -5$
$-4I_2 + I_1 = -5$
$I_2 = -5 + 4I_1$
$-4(-5 + 4I_1) + I_1 = -5$
$-16I_1 + 20 + I_1 = -5$
$-15I_1 = -25$
$I_1 = \frac{25}{15} = \frac{5}{3}$ A
$I_2 = -5 + 4(5/3)$
$= \frac{-15+20}{3}$ A

26. How is an ammeter constructed from a galvanometer? Sketch.

$I_3 = I_1 - I_2 = 0$

27. Approximately how long does it take charge to leave an initially charged capacitor C which is place in a series closed loop circuit with a resistor R?
(a) Q/C
(b) C/R
(c) RC
(d) Q/RC

28. How long does it take for charge build up on an initially uncharged capacitor C which is placed in a series circuit with a resistor R and a battery having a voltage V?
(a) V/RC
(b) V/R
(c) RC
(d) CV/R

29. What is the RC time constant?
(a) The relaxation time for a circuit in which a capacitor and a resistor are in series.
(b) The relaxation time for a circuit in which a capacitor and a resistor are in parallel.

30. What is the magnetic force on a particle with charge q moving at a velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$?
(a)$q\vec{B} \times \vec{v}$
(b)$q\vec{v} \times \vec{B}$
(c) $q\vec{v} \cdot \vec{B}$
(d)$q\vec{v}/\vec{B}$

31. If $\vec{v}$ is in the x direction and $\vec{B}$ is in the z direction, in which direction will the force be?
(a) x
(b) y
(c) z
(d) $-y$

32. What is a magnetic dipole?
(a) A current loop when viewed from very far away.
(b) A very small current loop
(c) A small bar magnet.

33. What causes the aurora borealis?
(a) The atmospheric ionization which occurs when electrons trapped in the Van Allen belt venture into the atmosphere at north pole.
(b) Magnetic thunderstorms over the north pole.

34. What is the most general trajectory of a charged particle in a uniform magnetic field?
(a) a circle
(b) a helix
(c) a straight line
(d) an ellipse

43. A long straight wire lays on the floor of a room. The wire carries a current I from south to north. What is the magnetic field direction a distance r to the east of the wire?

(a) *The field is directed out of the floor.*

(b) The field is directed into the floor.

(c) The field is directed west.

(d) The field is directed south.

44. What is the magnetic field due to a circular wire carrying a current I, at a distance z along the axis of symmetry perpendicular to the plane of the circle. The circle has a radius R.

(a) $\frac{\mu_0}{2}\frac{I R z}{(z^2+R^2)^{3/2}}$

(b) $\frac{\mu_0}{2}\frac{I R^2}{(z^2+R^2)^{3/2}}$

(c) $\frac{\mu_0}{2}\frac{I z^2}{(z^2+R^2)^{3/2}}$

(d) $\frac{\mu_0}{2}\frac{I}{(z^2+R^2)^{3/2}}$

45. What is the force (per unit length) between two parallel current carrying wires? The wires carry current in opposite directions.

(a) The force is attractive.

(b) The force is repulsive.

46. What is Ampere's law?

(a) The integral of the magnetic field around a closed loop is proportional to the current enclosed by the loop.

(b) The integral of the magnetic field around a closed loop is equal to zero.

47. What is the "law of no magnetic monopoles"?

(a) The integral of the magnetic field over any closed surface is equal to zero.

(b) The integral of the magnetic field around any closed loop is equal to zero.

48. Use Ampere's law to find the magnetic field due to a long solenoid.

49. Use Ampere's law to find the magnetic field due to a toroid.

50. Use Ampere's law to find the magnetic field from a long straight wire.

36. Describe the invention for which E. O. Lawrence won the Nobel prize in 1945.

(a) He invented the hydrogen bomb.

(b) *He invented the cyclotron, which accelerates charged particles to high energies*

(c) He invented the cathode ray tube and discovered the charge to mass ratio.

(d) He discovered the Hall effect, in which a transverse voltage develops across a conductor in a magnetic field.

37. What is the force on straight wire segment of length ℓ carrying a current I in the presence of a uniform magnetic field $\vec{B}$? The current is moving in the $\hat{k}$ direction and the magnetic field is directed in the $\hat{\imath}$ direction and has magnitude B.

(a) $I\ell B\ \hat{\jmath}$
(b) $-I\ell B\ \hat{\jmath}$
(c) $-I/(\ell B)\ \hat{\jmath}$
(d) $\ell B/I/\hat{\jmath}$

38. What is the torque on a current loop having area A and current I which is subjected to a magnetic field of magnitude B. The current loop lies in the $x-y$ plane, and magnetic field is directed along the $x-$ axis.

(a) $\vec{\tau} = IAB\ \hat{\jmath}$
(b) $\vec{\tau} = -IAB\ \hat{\jmath}$ one of these
(c) $\vec{\tau} = IAB\ \hat{\imath}$
(d) $\vec{\tau} = IAB\ \hat{k}$

39. What role do the brushes and commutators play in a dc electric motor?
(a) They switch the current direction through the armature every half cycle
(b) They keep the rotator clean for free movement.
(c) They generate a magnetic field by friction.
(d) They sweep the motor from one location to the next.

40. How should the coil be aligned in a suspended coil galvanometer.
(a) So that the area vector is perpendicular to the magnetic field.
(b) So that the area vector is parallel to the magnetic field.

41. What is the magnetic dipole moment of a current loop of area A and current I?

(a) A/I
(b) I/A
(c) IA
(d) I^2A