

AP Physics C: E&M Practice Worksheet

Fifty questions across electrostatics, capacitors, DC circuits, magnetic fields, and induction. Questions 45 to 50 ask for written explanations.

QUESTIONS	50	MULTIPLE CHOICE	14	WRITTEN	36
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Instructions

Draw the field or circuit before calculating. Track signs and directions carefully.

- 1** Find the force between two point charges of $+3 \times 10^{-6}$ C and $+2 \times 10^{-6}$ C separated by 0.5 m. ($k=9 \times 10^9$, $F=kq_1q_2/r^2$, round to 2 sig figs in scientific notation)

- 2** Find the electric field 3 m from a $+6 \times 10^{-6}$ C point charge. ($k=9 \times 10^9$, round to nearest whole number)

- 3** The electric field points:

 - A) From negative to positive charge
 - B) From positive to negative charge
 - C) Always upward
 - D) Only inside conductors
- 4** Inside a conductor in electrostatic equilibrium, the electric field is:

 - A) Maximum
 - B) Zero
 - C) Equal to the field outside
 - D) Undefined
- 5** Find the electric potential 2 m from a $+4 \times 10^{-6}$ C point charge. ($V=kq/r$, $k=9 \times 10^9$, round to nearest whole number)

- 6** Gauss's law is most useful when a charge distribution has:

 - A) No symmetry
 - B) Spherical, cylindrical, or planar symmetry
 - C) Only negative charges
 - D) Zero net charge always
- 7** A capacitor has charge 6×10^{-4} C and voltage 12 V. Find its capacitance.

- 8** A parallel plate capacitor has area 0.02 m^2 and separation 0.001 m. Find C. ($\epsilon_0=8.85 \times 10^{-12}$, round to 3 sig figs)

- 9** Find the energy stored in a 5×10^{-6} F capacitor charged to 100 V. ($U=0.5CV^2$)

- 10** Inserting a dielectric into a capacitor (keeping charge constant) does what to capacitance?

A) Decreases it
B) Increases it
C) No change
D) Makes it zero

- 11** Find the current through a 6 ohm resistor with 18 V across it.

- 12** Two resistors, 3 ohms and 5 ohms, in series. Find the equivalent resistance.

- 13** Two resistors, 4 ohms and 4 ohms, in parallel. Find the equivalent resistance. ($1/R_{eq} = 1/4 + 1/4$)

- 14** Kirchhoff's current law is based on conservation of:

A) Energy
B) Charge
C) Momentum
D) Mass

- 15** Kirchhoff's voltage law is based on conservation of:

A) Charge
B) Energy
C) Momentum
D) Current

- 16** A circuit has a 12 V battery and total resistance 4 ohms. Find the total current.

- 17** In an RC circuit, as a capacitor charges, the current in the circuit:

A) Increases over time
B) Decreases over time, approaching zero
C) Stays constant
D) Is always zero

- 18** Find the magnetic force on a charge $q=2 \times 10^{-6}$ C moving at $v=3 \times 10^5$ m/s perpendicular to $B=0.4$ T. ($F=qvB$, round to 2 sig figs in scientific notation)

- 19** The magnetic force on a charge moving PARALLEL to the field is:

A) Maximum
B) Zero
C) Equal to qvB
D) Negative

- 20** A wire carries 5 A current, length 2 m, in a field of 0.3 T, perpendicular. Find the force on the wire. ($F=BIL$)

- 21** Find the magnetic field 0.1 m from a long straight wire carrying 4 A. ($B=\mu_0 I / (2\pi r)$, $\mu_0=4\pi \times 10^{-7}$, round to 2 sig figs in scientific notation)

22 Ampere's law is most useful for finding the field of:

- A) Any arbitrary current distribution
- B) A highly symmetric current distribution
- C) A single stationary point charge
- D) A capacitor only

23 Find the magnetic flux through a 0.5 m^2 loop with $B=2 \text{ T}$ perpendicular to the loop. ($\phi=BA$)

24 Faraday's law relates induced EMF to:

- A) The magnitude of the magnetic field only
- B) The rate of change of magnetic flux
- C) The resistance of the circuit
- D) The charge of the loop

25 Lenz's law determines the direction of induced current by stating it:

- A) Always flows clockwise
- B) Opposes the change in flux that created it
- C) Always flows counterclockwise
- D) Is unrelated to flux direction

26 A loop's flux changes from 5 Wb to 2 Wb in 3 seconds . Find the magnitude of the induced EMF. ($\text{EMF}=-d(\phi)/dt$)

27 An inductor has $L=0.2 \text{ H}$ and current changing at 5 A/s . Find the induced voltage. ($V=L \times di/dt$)

28 Which best describes electrostatic shielding (a Faraday cage)?

- A) Field inside a hollow conductor from external charges is nonzero
- B) A hollow conductor blocks external electric fields from its interior
- C) Only magnetic fields can be shielded
- D) Shielding requires a charged conductor

29 Three identical 6-ohm resistors are all in parallel. Find the equivalent resistance. ($1/R_{eq} = 3/6$)

30 A capacitor fully charged in a DC circuit (steady state) allows:

- A) Maximum current to flow through it
- B) No current to flow through it
- C) Current equal to the battery current
- D) Negative current

31 Find the resistance of a wire with resistivity $1.7 \times 10^{-8} \text{ ohm} \cdot \text{m}$, length 2 m , and cross-sectional area $1 \times 10^{-6} \text{ m}^2$. ($R = \text{resistivity} \times L / A$)

32 Which quantity does NOT depend on the path taken, only on start and end points?

- A) Work done by friction
- B) Electric potential difference (voltage)
- C) Distance traveled
- D) Heat generated by resistance

33 A positive charge moves from high potential to low potential. Is its potential energy increasing or decreasing?

- 34** Explain why the electric field inside a conductor in electrostatic equilibrium must be zero.

- 35** Explain, using Lenz's law, why a magnet falling through a copper tube falls more slowly than through the air.

- 36** Explain why adding more resistors in parallel decreases the equivalent resistance of a circuit, even though more resistors are being added.

- 37** Explain why work done by the electric force on a charge moving along an equipotential surface is always zero.

- 38** Explain how a capacitor stores energy in terms of the electric field between its plates, not just as charge on the plates.

- 39** Explain why a current-carrying wire experiences no net force when placed parallel to a uniform magnetic field.

- 40** Two capacitors are connected in series. Explain why the equivalent capacitance is smaller than either individual capacitance, contrasting with resistors in series.

- 41** Explain the physical meaning of the time constant RC in an RC charging circuit.

- 42** Explain why two parallel wires carrying current in the same direction attract each other, using the right-hand rule and the force on a current in a magnetic field.

- 43** Find the potential energy of two point charges $+2 \times 10^{-6} \text{ C}$ and $-3 \times 10^{-6} \text{ C}$ separated by 0.3 m . ($U = kq_1q_2/r$, $k = 9 \times 10^9$)

- 44** An RC circuit has $R = 2000 \text{ ohms}$ and $C = 5 \times 10^{-6} \text{ F}$. Find the time constant $\tau = RC$.

- 45** Find the magnetic field inside a solenoid with $n = 1000$ turns/meter carrying 2 A . ($B = \mu_0 n I$, $\mu_0 = 4\pi \times 10^{-7}$, round to 2 sig figs)

- 46 Two parallel wires each carry 3 A, separated by 0.2 m. Find the force per unit length between them.
($F/L = \mu_0 \times I_1 \times I_2 / (2 \times \pi \times d)$)

- 47 A parallel plate capacitor has voltage 100 V and plate separation 0.002 m. Find the electric field between the plates. ($E = V/d$)

- 48 A conducting rod of length 0.5 m moves at 4 m/s perpendicular to a 0.2 T field. Find the induced EMF.
($EMF = BLv$)

- 49 A circuit has voltage 24 V and current 3 A. Find the power delivered. ($P = IV$)

- 50 Two 10 microfarad capacitors are connected in series. Find the equivalent capacitance.

Answer key

Direct answers only, in question order. Work the set first, then check.

1. 0.22 N	2. 6000	3. B) From positive to negative charge	4. B) Zero	5. 18000
6. B) Spherical, cylindrical, or planar symmetry	7. 5e-05	8. 1.77×10^{-10} F	9. 0.025	10. B) Increases it
11. 3.0	12. 8	13. 2	14. B) Charge	15. B) Energy
16. 3.0	17. B) Decreases over time, approaching zero	18. 0.24 N	19. B) Zero	20. 3.0
21. 8.0×10^{-6} T	22. B) A highly symmetric current distribution	23. 1.0	24. B) The rate of change of magnetic flux	25. B) Opposes the change in flux that created it
26. 1.0	27. 1.0	28. B) A hollow conductor blocks external electric fields from its interior	29. 2	30. B) No current to flow through it
31. 0.034	32. B) Electric potential difference (voltage)	33. Decreasing	34. If a field existed inside a conductor, free charges would experience a force and continue moving until they redistribute to cancel the internal field, so at equilibrium (no further charge movement) the field inside must be exactly zero	35. As the magnet falls, it creates a changing flux in the copper tube, inducing eddy currents; by Lenz's law, these currents create a magnetic field opposing the magnet's motion, producing a retarding force that slows its fall

36. Each additional parallel branch provides another path for current to flow, effectively increasing the total cross-sectional area available for current, so the overall resistance to current flow decreases even as the number of components increases
37. Work equals the charge times the potential difference between two points; since every point on an equipotential surface has the same potential, the potential difference is zero, so no work is done moving along that surface
38. As charge accumulates on the capacitor's plates, it creates an electric field in the region between them; the energy of the capacitor is actually stored in this electric field itself, and the field's strength depends on both the charge and the geometry of the capacitor
39. The magnetic force on a current is $F = BIL \sin(\theta)$, where θ is the angle between the current direction and the field; when the wire is parallel to the field, $\theta = 0$, and $\sin(0) = 0$, so the force is zero
40. In series, capacitors share the same charge, and the total voltage divides across them additively as $V = Q/C$ for each, so adding more capacitors in series is like increasing the effective plate separation, making it 'harder' to store charge and lowering equivalent capacitance, unlike resistors where series connection simply adds resistances directly
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41. The time constant RC represents the time it takes for the capacitor's voltage (or charge) to reach about 63% of its final value; a larger R or C means the capacitor takes longer to charge, since more resistance limits current flow and more capacitance requires more charge to reach the same voltage
42. Each wire creates a magnetic field that curls around it according to the right-hand rule; at the location of the second wire, this field points in a direction such that, combined with the second wire's current direction, the resulting force (via $F = IL \times B$) points toward the first wire, and by symmetry the same is true in reverse, so the wires attract
43. -0.18
44. 0.01
45. $2.5 \times 10^{-3} \text{ T}$

46. $9.0 \times 10^{-6} \text{ N/m}$

47. 50000.0

48. 0.4

49. 72

50. 5 microfarads

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Questions I answered incorrectly:

Was it the physics model, the calculus setup, or the evaluation?

The single topic I want to start the next session with:
