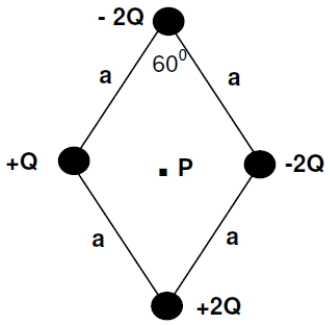
Practice Problems, Physics 121, Common Exam 2, Spring 2025

Chapters: 22, 23, 24, 25, 26

1.

Four point charges are located at the corners of a diamond-shaped parallelogram as shown in the sketch. The value of Q = 20 μC. The length of each side of the figure is a = 30 cm, with an 60^0 angle located as shown. The potential at infinity is the zero reference level. Find an expression for the electric potential V at point P, the center of the diamond shape. Note: k_e is the constant $1 / 4\pi\varepsilon_0$

A) V = 0
B) V = $2k_eQ$ / a.sqrt(3)
C) V = $-4k_eQ$ / a
D) V = $-k_eQ$ / a.sqrt(3)
E) V = $-2k_eQ$ / a



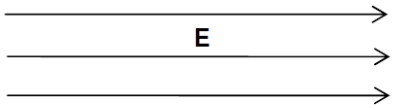
2.

A metal sphere is charged to a potential of 300 volts. Its radius is 2 meters. The potential at a point 1 meter from the center of the sphere is:

A) 300 V.
B) -100 V.
C) – 300 V.
D) 0 V.
E) 100 V.

3.

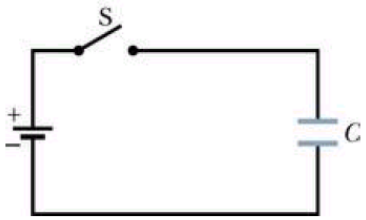
An electron is moved through a displacement Δx parallel to the direction of a uniform electric field. During this displacement:



A) the potential energy of the electron and the electric potential do not change.
B) the potential energy of the electron increases, the electric potential increases.
C) the potential energy of the electron increases, the electric potential decreases.
D) the potential energy of the electron decreases, the electric potential decreases.
E) the potential energy of the electron decreases, the electric potential increases

4.

The capacitor in the sketch has a capacitance of 24.0 μF and is initially uncharged. The battery maintains a potential difference of 3.0 V. How much total charge flows out of the battery until the capacitor is fully charged (the current stops flowing)?



A) 3.20 μC
B) 8.00 μC
C) 72.0 μC
D) 12,000 μC
E) 30.0 μC

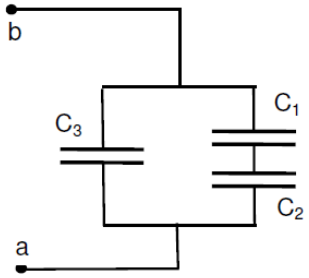
5.

A parallel plate capacitor being designed is supposed to have a capacitance of 400 pF (1 pF = 10^{-12} F = 10^{-6} μF). It will be filled with a material whose dielectric constant is close to 1.5 (glass). The distance between plates will be 0.3mm. Approximately, what should the area of the plates be?

A) 1.10 m^2
B) 0.028 m^2.
C) 0.014 m^2.
D) 0.009 m^2.
E) 0.9 m^2.

6.

Three capacitors are connected in the series/parallel arrangement shown in the sketch. Suppose C_1 = 30μF, C_2 = 30μF, and C_3 = 15μF. The potential difference across the combination V_{ab} = 40 V. The equivalent capacitance between points a and b is closest to:



A) 15 μF
B) 30 μF
C) 7.5 μF
D) 45 μF
E) 12 μF

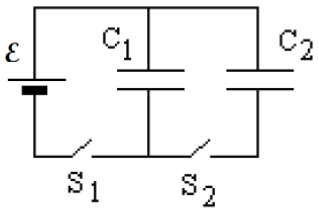
7.

In problem 6, calculate the voltage across capacitor C_2 (in volts)

A) 60
B) 40
C) 10
D) 20
E) $6x10^{-4}$

8.

In the circuit shown in the sketch, switches S_1 and S_2 are initially open. Capacitor C_1 = 30.0 nF is then charged by closing switch S_1 which connects it to the battery whose EMF $\mathcal{E}$ = 90 V. Switch S_1 is then opened, thereby disconnecting C_1 from the battery. Switch S_2 is then closed, thereby connecting the charged capacitor C_1 to the uncharged 15.0 nF capacitor C_2. Find the final potential difference across capacitors C_1 and C_2. (Hint: after being disconnected, the total charge on the combination C_1, C_2 remains constant).



A. 60 V
B. 30 V
C. 4 V
D. 10 V
E. 120 V

9.

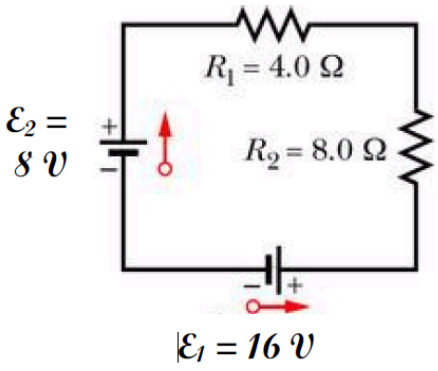
For the previous problem, the final charge on capacitor C_1 is closest to:

A) 2.0 μC
B) 0.8 nC
C) 0.2 μC
D) 1.2 nC
E) 1.8 μC

10.

Assume that the batteries in the figure have negligible internal resistance. Assume that the current flows counterclockwise. Find the magnitude of the current in the circuit and the power dissipated in resistor R_1.

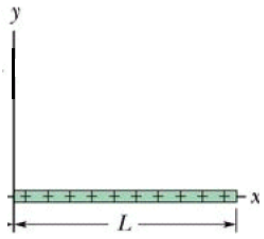
A) i = 0.67 A, P_1 = 2.7 watts
B) i = 1.33 A, P_1 = 5.4 watts
C) i = 1.5 A, P_1 = 24 watts
D) i = 0.67 A, P_1 = 1.8 watts
E) i = 1.5 A, P_1 = 9 watts



11.

The figure shows a plastic rod of length L = 2.5 m, with a non-uniform linear charge density $\lambda = \alpha x$ with $\alpha = 10^{-3}$ C/m^2. The rod is lying on the x axis. Assuming V = 0 at infinity, find the electric potential (in volts) at the left end of the rod – in other words, at the origin. Select the closest answer.

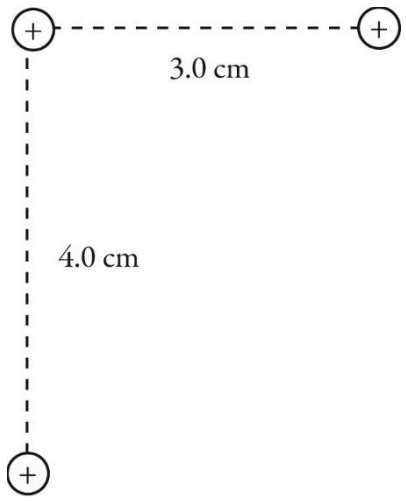
A) Zero
B) 2.7×10^{10} volts
C) 2.25×10^{7} volts
D) 1.35×10^{8} volts
E) Infinity



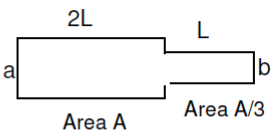
12.

Potential energy of point-charges: Consider the group of three+2.4 nC point charges shown in the figure. What is the electric potential energy of this system of charges relative to infinity?
($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C^2)

A) 4.1×10^{-6} J
B) 4.6×10^{-6} J
C) 4.2×10^{-6} J
D) 4.4×10^{-6} J



13. Two wires made of the same material are joined end-to-end and a potential difference is maintained across the combination, from a to b in the sketch. The thin wire has cross sectional area A/3 and length L. The fatter wire has area A and length 2L. Which of the following quantities are the same for both wires:



1. The resistivity of each wire
2. The resistance of each wire
3. The current density inside each wire
4. The current through each wire
5. The potential difference across each wire

A) 1, 2, and 3 B) 1, 2, 4, and 5 C) 1 only D) 2 only E) 1 and 4 only

14.

A certain electric furnace consumes 24 kW when it is connected to a 240-V line. What is the resistance of the furnace?

A) 1.0 kΩ
B) 10 Ω
C) 2.4 Ω
D) 0.42 Ω
E) 100 Ω

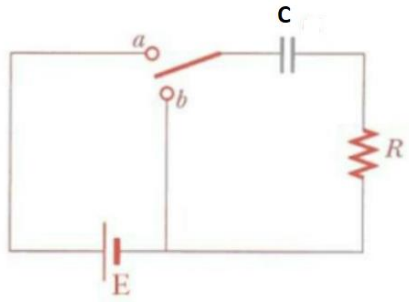
15.

A 1500-W heater is connected to a 120-V line. How much heat energy does it produce in 2.0 hours?

A) 1.5 kJ
B) 3.0 kJ
C) 0.18 MJ
D) 11 MJ
E) 18 MJ

16.

The sketch at right shows a series RC circuit. The applied EMF E = 12 V., R = 1.0 MΩ, and C = 5.0 μF. The capacitor is initially uncharged. After the switch is closed at point "a", how long does it take for the charging current through the resistor to fall to 30% of its initial value? Select the closest answer:



A) 6.0 sec
B) 80 sec
C) 0.3 sec
D) 3.0 sec
E) 1.2 sec

17.

The capacitor in a single-loop *RC* circuit is discharged to 25% of its initial potential difference in 60 s. What is the time constant for this circuit?

A) 0.5 s
B) 60 s
C) 23.0 s
D) 0.043 s
E) 43.3 s

18.

The figure at right shows an ideal battery with E_2 = 3 V. and a real battery E_1 = 4 V whose internal resistance r = 1 Ω. Both EMF's are connected to a 3 Ω resistor. What is the current through the 1 Ω resistor?

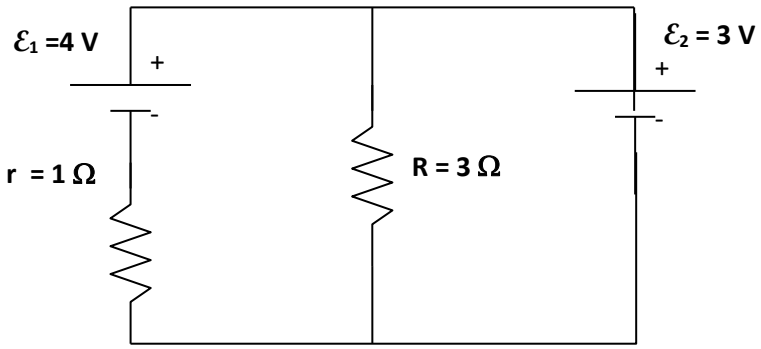
A) 1.33 A

B) 1.25 A

C) 1.0 A

D) 2.0 A

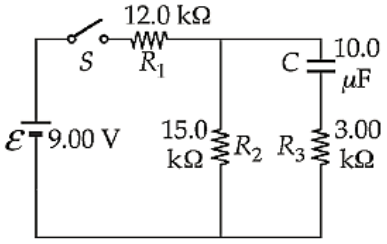
E) 3.0 A



19.

Suppose the switch has been closed for a time interval sufficiently long for the capacitor to become fully charged. Find the charge on the capacitor.

A) 0.045C
B) 0. 75 mC
C) 12 x10^{-6}C
D) 2 .0 C
E) 50 µC



20.

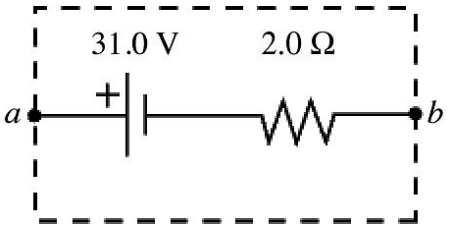
An electron is released from rest at a distance of 9.00 cm from a proton. If the proton is held in place, how fast will the electron be moving when it is 3.00 cm from the proton? ($m_{el} = 9.11 \times 10^{-31}$ kg, $e = 1.60 \times 10^{-19}$ C, $k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C^2)

A) 75.0 m/s
B) 106 m/s
C) 130 m/s
D) 1.06×10^3 m/s
E) 4.64×10^5 m/s

21.

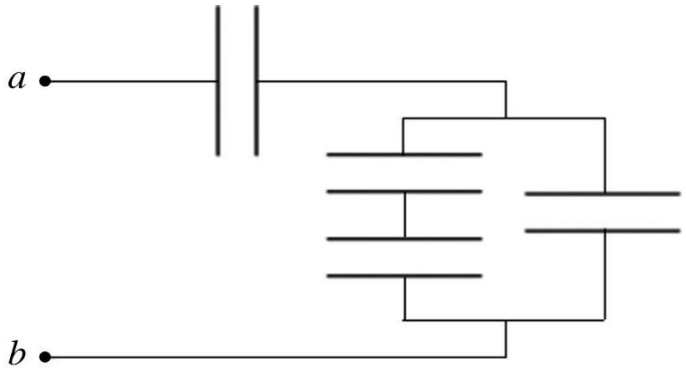
The emf and the internal resistance of a battery are as shown in the figure. When the terminal voltage V_{ab} is equal to 17.4 V, what is the current through the battery, including its direction?

A) 6.8 A, from *b* to *a*
B) 8.7 A, from *b* to *a*
C) 6.8 A, from *a* to *b*
D) 8.7 A, from *a* to *b*
E) 16 A, from *b* to *a*



22.

The capacitors in the network shown in the figure all have a capacitance of 5.0 μF. What is the equivalent capacitance, C_{ab}, of this capacitor network?



A) 20 μF
B) 3.0 μF
C) 10 μF
D) 5.0 μF
E) 1.0 μF

23.

A 6.00-μF parallel-plate capacitor has charges of ± 40.0 μC on its plates. How much potential energy is stored in this capacitor?
A) 103 μJ
B) 113 μJ
C) 123 μJ
D) 133 μJ
E) 143 μJ

24.

A parallel-plate capacitor consists of two parallel, square plates that have dimensions 1.0 cm by 1.0 cm. If the plates are separated by 1.0 mm, and the space between them is filled with teflon, what is the capacitance of this capacitor? (The dielectric constant for teflon is 2.1, and $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$.)

A) 1.9 pF
B) 0.44 pF
C) 2.1 pF
D) 0.89 pF
E) 4.51 pF

25.

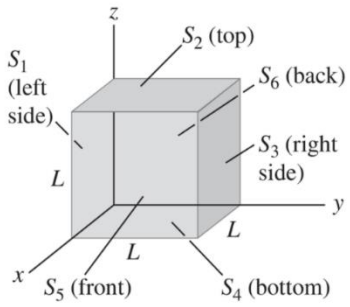
A point charge with a charge $q_1 = 3$ nC is held stationary at the origin. A second point charge $q_2 = 17$ nC moves from the point x = 0.17 m, y = 0 to the point x = 0.24 m, y = 0.08 m. How much work is done by the electric force on q2?

A) 3.1×10^{-7} J
B) 4.2×10^{-6} J
C) 5.3×10^{-6} J
D) 8.8×10^{-7} J
E) 9.23×10^{-6} J

26.

The cube in Fig. E22.6 has sides of length L=10.0 cm. The electric field is uniform, has magnitude $E=4.00\times10^3$ N/C, and is parallel to the xy-plane at an angle of 53.1° measured from the +x-axis toward the +y-axis. (a) What is the electric flux through each of the six cube faces S_1, S_2, S_3, S_4, S_5, and S_6? (b) What is the total electric flux through all faces of the cube?

Figure E22.6



Ans.

a) S1: $-32\ \mathrm{N\cdot m^2/C}$

S2: 0

S3: + $32\ \mathrm{N\cdot m^2/C}$

S4: 0

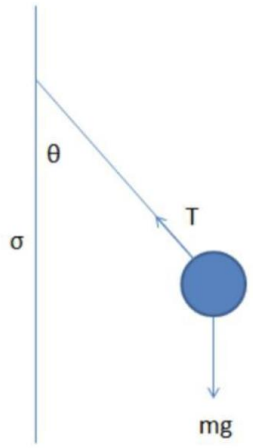
S5: + $24\ \mathrm{N\cdot m^2/C}$.

S6: - $24\ \mathrm{N\cdot m^2/C}$.

b) total flux will be zero

27.

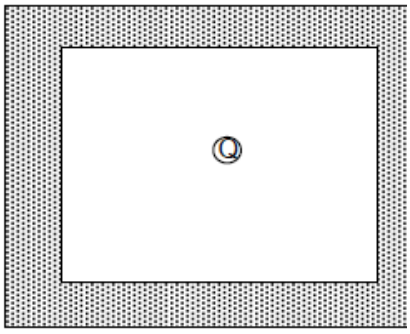
A small sphere with mass m carries a positive charge q and is attached to one end of a silk fiber of length L. The other end of the fiber is attached to a large vertical insulating sheet that has a positive surface charge density σ. Show that when the sphere is in equilibrium, the fiber makes an angle equal to arctan (qσ/2mgϵ0) with the vertical sheet.



28.

A negative charge Q = - 2 μC is placed inside a neutral cubical conducting box with a cavity in it. The length of the side of the inner cavity is a and the outer box's side length is b. What charges will be induced at the inner and outer surfaces of the box?

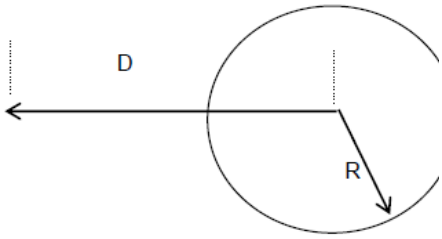
A) Inner charge = –2 μC. Outer charge = +2 μC
B) Inner charge = +2 μC. Outer charge = -2 μC
C) Inner charge = 0 μC. Outer charge = -2 μC
D) Inner charge = +2 μC. Outer charge = 0 μC
E) Inner charge = 0 μC. Outer charge = 0 μC



29.

A solid, conducting sphere has a net positive charge of Q = 4.5 C on it. It's radius R is 3.0 m. What is the magitude of the electric field at a distance D of 9.0 m. from the center of the sphere.

A) 9×10^9 N/C
B) 0.0 N/C
C) 1.0×10^9 N/C
D) **5×10^8 N/C**
E) 1.0×10^8 N/C



30.

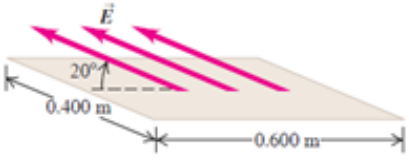
For same solid, charged conducting sphere of the problem above, find the magnitude of the electric field at a distance D = 0.5 m. from the center of the sphere.

A) 9.0 x 109 N/C
B) 0.0 N/C
C) 1.0 x 109 N/C
D) 0.5 x 109 N/C
E) 2.25 x 109 N/C

31.

A flat sheet is in the shape of a rectangle with sides of lengths 0.400 m and 0.600 m. The sheet is immersed in a uniform electric field of magnitude 60.0 N/C that is directed at 20° from the plane of the sheet as it is shown in the figure. Find the magnitude of the electric flux through the sheet.

A) 9.2 N·m^2/C
B) 5.3 N·m^2/C
C) 2.3 N·m^2/C
D) 2.8 N·m^2/C
E) 4.9 N·m^2/C



ANSWER KEY:

1. E
2. A
3. C
4. C
5. D
6. B
7. D
8. A
9. E
10. D
11. C
12. A
13. E
14. C
15. D
16. A
17. E
18. C
19. E
20. B
21. A
22. B
23. D
24. A
25. D